



The Blast Furnace and Steel Plant

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The Blast Furnace *and* Steel Plant

Vol. X

PITTSBURGH, PA., JUNE, 1922

No. 6

American Iron and Steel Institute Meeting

Fifteen Hundred Steel Men Attend the Twenty-first General Meeting—Valuable Technical Papers Read—Judge Gary's Address Features the Meeting.

THE twenty-first general meeting of the American Iron and Steel Institute was held at the Commodore Hotel, New York, on May 26. There were three sessions, the forenoon and afternoon sessions being devoted to the address of Judge Gary and the reading of a number of the technical papers. In the evening a banquet was held. The technical program presented at this meeting was very interesting. The papers read were as follows:

Address of the President, Elbert H. Gary, Chairman United States Steel Corporation, New York.

"The Development of the Iron and Steel Industry of Australia," David Baker, General Manager, The Broken Hill Proprietary Company, Newcastle, N. S. W., Australia.

"The Relation of the Doctor to the Steel Plant," Loyal A. Shoudy, Chief Surgeon, Bethlehem Steel Corporation, Bethlehem, Pa.

"Industrial Housing," C. L. Wooldridge, General Superintendent, Carnegie Land Company, Pittsburgh, Pa.

"The General Effect of Electrification of Steel Mills Upon Their Operation," Wilfred Sykes, Assistant to Operating Vice President, Steel & Tube Company of America, Chicago, Ill.

"The Importance of the Iron Ores of the Adirondack Region," Frank L. Nason, Geologist, West Haven, Conn.

"Methods of Using Fuel in Open Hearth Furnaces," W. C. Bulmer, Superintendent, Open Hearth Department, Ohio Works, Carnegie Steel Company, Youngstown, Ohio.

Part of the papers which were read are contained in this issue of THE BLAST FURNACE AND STEEL PLANT. Others will appear next month.

Judge Gary in his annual address said in part:

Since the armistice of 1918 I have never spoken publicly without referring, though with brevity, to the signs of danger and depression, the possibility of demoralization and disaster as the result of the military cataclysm which for four years and more convulsed the world. We have not, I think, entirely passed from under the clouds of adversity. Certainly we are carrying hitherto unheard-of heavy governmental financial burdens. At best, these will not soon be fully discharged. To bear them grace-

fully and contentedly there must be not only forbearance, encouragement and assistance from every department of government up to the limit of propriety and justice, but there must also be entertained by every individual, consistently and constantly, a spirit of patience, pluck, energy, generosity, loyalty and charity fully up to his or her highest intelligence.

Gentlemen here assembled, we must do our part. We must be fair and just, as loyal to the Government as we were during the war. We must treat others in such manner as to be entitled to their approval.

Little need be said about the changed and changing business conditions for the better in the iron and steel industry. The facts and figures have been and are being published. The volume is large and increasing. The profits are not satisfactory, but few, if any, ought to be doing business at a loss, and we shall soon, I hope, settle down to a readjusted basis of prices and rates that is fair and reasonable and on a comparative parity. Let us be moderate in our demands. Profiteering will be more and more exposed and eliminated. I could if necessary refer to some outrages which still exist; but the general public, when correctly informed, is disposed to be just and it will not long overlook nor condone the exceptional glaring injustices that still obtain in prices and rates.

Ever since the armistice was signed, when I have spoken it has been hopefully as to the long business future. I am still an optimist. And likewise are you. It is seen in your countenances. Big, even profitable, business has been ahead of us all these years, though it has been at times obscured. Now we seem to be nearer a realization. But every one in official or private life, employers and workmen, professionalists, merchants, financiers, mechanics, artisans, all, properly supported by our Government, may and will, as never before, utilize to the greatest advantage of our own people and others the existing and productive wealth of this great country.

Optimism arises from opening one's eyes and ears and mind to the good things in life which a merciful and overruling Providence has bestowed. May all of us have sense to appreciate. Pity the chronic blind, deaf and foolish pessimist of the United States.

The prosperity and welfare of all the people depend upon the enactment, the administration and the enforcement of law. It furnishes the fundamental distinction between human beings of today and the cave dwellers of the past.

All fair-minded, right thinking men and women will agree that laws should be adopted, maintained and enforced strictly on the basis of equal opportunity and equal responsibility to every man, woman and child, wherever located and whatever the surrounding circumstances may be.

Any law in its existence or administration that discriminates in favor of or against any individual, calling or location is essentially wrong and is injurious to the whole body politic. Any person who, for selfish reasons or as an advocate for another, insists upon a claim contrary to the one expressed is disloyal to the principles of our national scheme of government.

These principles should always be borne in mind by the executive, the legislative and the judicial departments of government; by the farmer, the merchant, the banker, the carrier, the manufacturer, the miner, the employer, the employee, the possessors of capital and the impecunious; and in these days particularly they should be constantly emphasized in the minds of all professionals—those who attempt to instruct or to minister to the wants of others.

I trust we of the iron and steel industry are conscious of our obligations to the laws of the land, to the general public and to our neighbors, those with whom we come into business contact. This should be our constant thought and study. This is a substantial part, nay, the controlling spirit of this Institute.

On the other hand, we have the right to insist that all others shall be required to conform to the same strict accountability; and that we shall receive the same protection and benefits that are accorded to others. As the prosperity of the country is vitally affected by the passage and administration of laws, even by the tinkering of legislation, so called, it is deemed appropriate to discuss before the business men of an important manufacturing industry some of the current proposed legislation, even though what we may say or think may have little influence.

There should be a commission of well paid, high minded, intelligent, competent and non-partisan appointees, authorized to

ascertain and communicate the facts and figures, and their reports should be frequent so that, if deemed necessary, a change or amendment to the tariff laws could be made at any time Congress is in session.

The head of the great steel trust declared he welcomed fair laws for the regulation of industry or investigations that were honest and non-partisan. He said:

The progress and prosperity of no nation can long endure if any single factor in economic life shall be especially favored or punished or exempted.

He therefore contended, he said, that trade unions and farmers' organizations should be subject to exactly the same kind of regulation as industrial and commercial organizations.

Mr. Gary opposed immediate passage of soldier bonus, because "the load of taxation ought to be lightened, not increased." If passed at a later date he expressed strong approval of the sales tax as a method of raising the money.

Gas and Air Valves for Open Hearth Furnaces

Discussion of the Development of the Various Types of Valves
for Which Each Inventor Claims Some Superiority.

By WILLIAM C. BULMER,* Superintendent,
Open Hearth and Bessemer Depts., Ohio Works, Carnegie Steel Company, Youngstown, Ohio

AS the early metallurgist had little if any knowledge of gaseous fuels, it follows that he knew nothing of their application in his furnace. His experience was confined to the burning of solid fuels, such as wood and charcoal, and later to the organic deposits of the earth, of which coal, peat and lignite are examples. It is reasonable to assume that one of his very first problems included the regulation of temperature, which he solved by the use of the forced blast of the bellows. With the increase of his knowledge he learned that a further regulation of temperature was necessary, and we find him placing a movable cover over his chimney, or a damper or slide in the flue leading to it, whereby the passage of the waste gases to the atmosphere might be constricted at will or as his process demanded. He augmented this by the use of doors covering the opening through which he introduced his fuel, and over the pit from which the ash was removed. These contrivances not only permitted him to govern his temperature, but they also provided a means whereby he could control the character of the reactions taking place in his furnace, and we find him able to produce a reducing atmosphere, where one of an oxidizing nature did not suit his process.

In the development of the early blast furnace, it was discovered that large quantities of useful fuel, escaping from the top in the form of a gas, might be utilized for preheating the blast air for the furnace. This was accomplished by burning the gas in a chamber, through which the air was passed by means of cast iron pipes or conduits. From this grew the practice of burning the gas

in a series of chambers and alternately passing the blast air through them before it entered the furnace. These inventions made possible the saving of more than one-half of the fuel otherwise necessary for the process.

The experiments of William and Frederick Siemens in the production of steel in reverberatory furnaces began as early as 1856. They found that they could not successfully obtain the results desired by the use of cold air in the combustion of their fuel, which led to the adoption of the regenerative principle characteristic of open hearth furnaces. Higher temperatures and an economy in the consumption of fuel were a natural consequence.

As all regenerative types of furnaces require a periodic reversal of the flow of gases through them, some mechanical agency must be employed to cause the change of direction. The simplest device for this purpose is the butterfly valve, and naturally it was the one first adopted. It served the purpose and would be the ideal contrivance if the material of which it is made did not become distorted through the expansion and contraction caused by the variation of temperature to which it is subjected. Its use for the regulation of the air has been more or less satisfactory, and in some cases it still survives as an adjunct to certain classes of air valves, but its application to the reversal of gas has not met with favor.

Apparently little effort was made towards the improvement of the early valves until the year 1889, when a water-cooled butterfly valve was installed at No. 2 open hearth plant of Carnegie, Phipps & Company at Homestead. The idea, of course, was to prevent distortion, but difficulty was encountered in keeping it watertight and it was replaced by a cast iron one of the dry

*Abstract of paper presented before American Iron and Steel Institute, New York, May 26, 1922.

class. This, in turn, gave way to the double-seated mushroom valve in 1900.

Minimum Resistance to Flow of Gases.

The chief requisites of a proper valve are an effective seal and an unrestricted passage. The choice of a valve requires most careful consideration, as upon the fulfillment of certain requirements depends the successful operation of the furnace. In order of importance we should consider, first, the valve having the minimum resistance to the flow of gases, combined with the least amount of leakage past the valve.

From investigation of installations now in use, it can be safely stated that the effective draft in the flue leading from the checkers will seldom be over 50 per cent of that found at the base of the stack. To determine the cause of draft failure, in the early stages of the campaign

of the gas in passing through the valve formed zones of eddy currents which resulted in a partial vacuum. The moving of the pressure testing pipe across the area of the valve port would show readings varying from .4 in. to minus .1 in. water column. Needless to say, the actual area of flow through the port was considerably less than the total area, which of itself was too small for the amount of gas to be handled. Not only did the four right angle turns, necessitated in the flow of the gas out of the flue through the valve and back to the flue, cause serious frictional losses, but the impingement of the gas on the extending water seal was also a detrimental factor.

Resistance to flow through the valves has a very bad effect on the operation of any furnace, as the slowing up in the time of heats and the final shutting down of the furnace on account of the clogging of the air checkers are largely due to the lack of sufficient draft to pull the

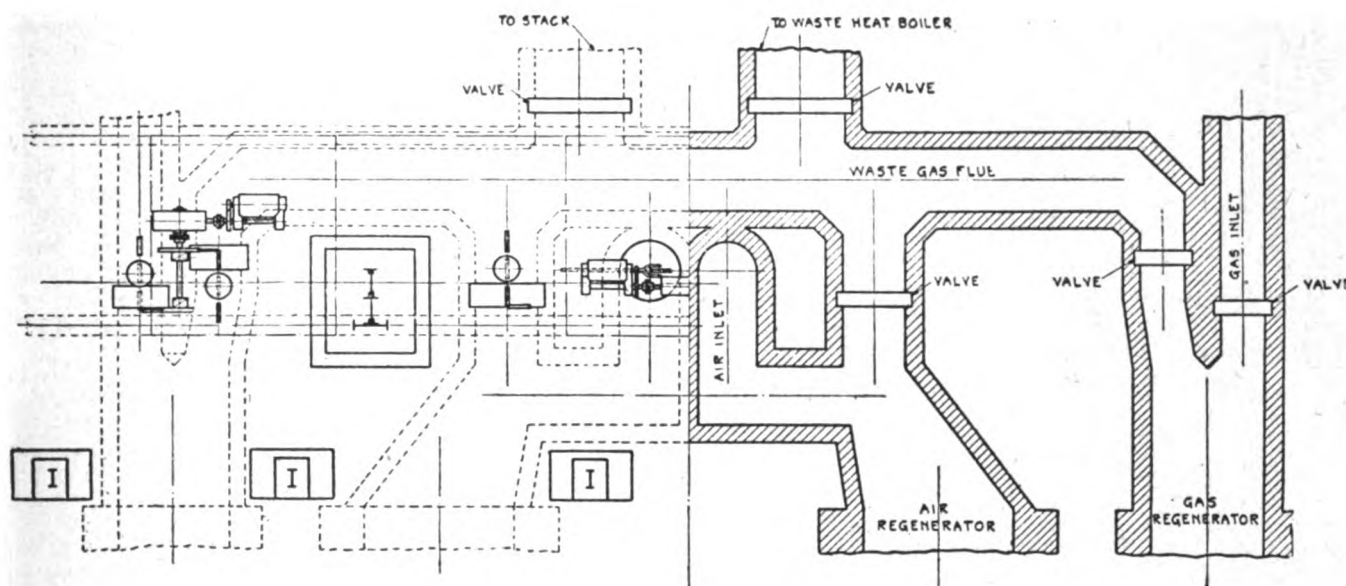


Fig. 1—Arrangement of flues for Knox Valves.

on furnaces at South Chicago, measurements were taken throughout the entire system of flues between the regenerative chambers and the stack. The gas valve was of a well known type used in conjunction with a butterfly air valve, and when measurements were taken in the flue on each side of these valves there was found to be a frictional loss amounting to 52 per cent of the stack draft. This is not at all an unusual condition, as installations have been found where the effective draft in the checker flues was only 30 per cent of that of the stack. In a heating furnace at South Chicago, on account of a difficulty existing in the draft, a considerably higher stack was built before an investigation of the conditions was made. As little improvement was found in the working of the furnace, a search was made to determine the cause of the trouble and it was found that the loss of draft, due to the valve and turns leading to and from it, amounted to 72 per cent of the stack draft. Obviously, in this case, the valves were altogether too small for the furnace. I have known of measurements being made at various plants on the draft loss due to the valves, and in no case have I found it to be less than 27 per cent, and this on a furnace where the valves were of rather ample size. In another investigation as to draft and pressure conditions existing through a gas valve, portions of the producer gas port of the valve were found to show a negative reading. This indicated only that the churning

waste gases through the restricted opening. The dirt will accumulate in inverse proportion to the draft at the checkers, and only a sufficient pull at all times will insure a sharp working furnace. It is not difficult to decide, therefore, that the type of valve to choose is one that will permit of the draft at the checkers being as near to that of the stack as possible.

In addition to the valves, another factor which should be considered with reference to a free flow of the gases is the directness of flue passage with the shortest possible length, not only between the furnace and the stack, but also between the gas producers and the valves. Sharp turns in the flues, poorly designed valves, or a combination of both, will have a very detrimental effect upon the working of the gas producers, as it requires excessive pressure to drive the gas to the furnace, resulting in poor gas and improper producer operation. Many installations of restricted valves with poorly designed flues will be unable to properly procure a sufficient supply of good gas to operate to the best advantage with the adoption of the present day sharp working furnace, but in many cases this can be materially improved by the adoption of a valve having unrestricted passage.

Advantages of the One-Way Valve.

Valves may be divided into three groups, namely: one-day, two-way and four-way, depending upon the

number of directions of gas or air passage through them. Those of the one-way group are the only ones which offer means of regulating the flow of gases to and from each checker chamber separately without additional equipment in the form of extra dampers or valves.

If a furnace is designed for proper distribution of the waste gases between the air and gas checkers, this distribution will not be maintained for long without proper valve regulation. The accumulation of dirt in the

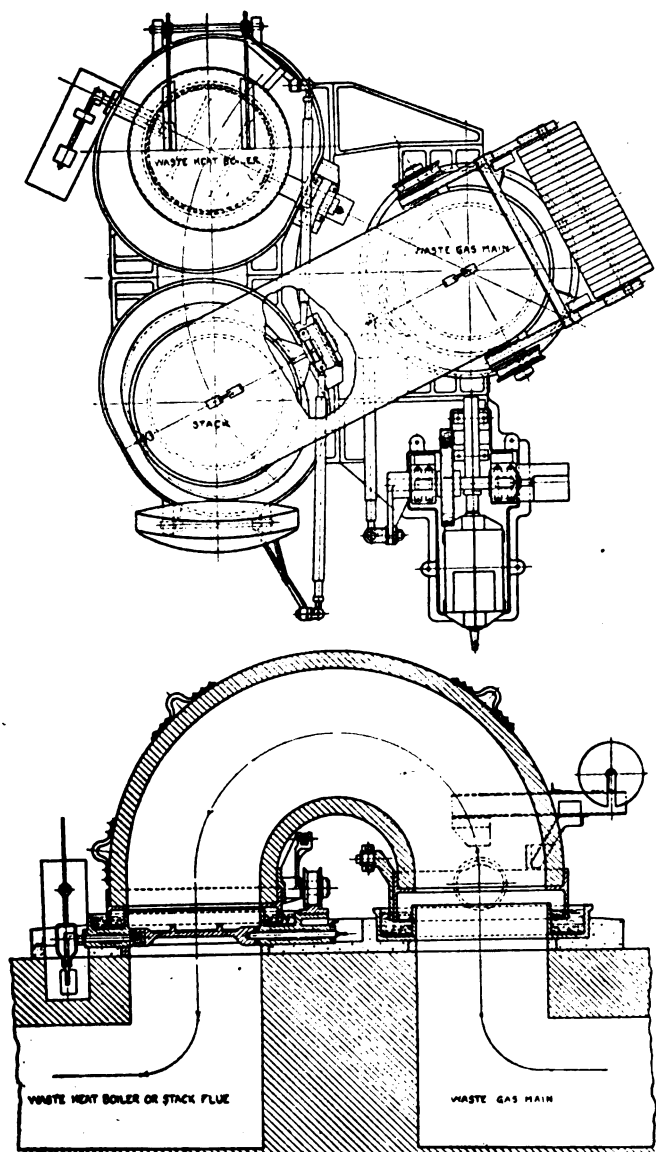


Fig. 2—The Blair valve.

air checkers will add frictional resistance, which will decrease the proportionate amount of waste gases going through these checkers and the furnace will soon be thrown out of balance. By the use of a one-way valve, manipulation of the floor stands can be made to open the valve to any required degree, and at all times in the furnace campaign any desired proportion of the waste gases can be put through either of the chambers. The same regulation of the incoming gas can be made to offset the disadvantage of unequal port areas on either end of the furnace. This regulation should be particularly useful in a plant which does not run through Sundays. With only sufficient gas kept on the furnace during the Sunday shutdown to keep the furnace hot, the air chambers usually become much colder than the gas

chambers and it is not until two or three days later that the temperature of the chambers is properly balanced. With a single-way valve installation, the regulation can be made such that practically all the waste gases, during the period in which the furnace is simply being kept warm, can be caused to go to the air chambers, thus keeping them up to a much better temperature than would otherwise be the case.

Another advantage of a single-way valve is that it can be adapted to any desired flue layout and could often be readily installed to correct present difficulties, due to poor flue arrangement, with a poorly constructed valve that might be in use. For waste heat boiler work a valve giving straight line flow with a minimum of exposed water-cooling will give the best results. Not only does this type of valve insure higher waste gas temperature to the boilers, but because of their offering practically no resistance to the passage of the gases, they require less power for operating the boiler fan. The argument might be offered that where waste heat boilers are used, sufficient draft can always be obtained by the use of a sufficiently large fan, but this would be poor reasoning, for if between the stack and furnace ports certain frictional resistance can be tolerated, it is much better to have this resistance offered by a closer laying of checkers than by unnecessary resistance through the valves or with normal areas through the checker chamber. The less the resistance offered by the valves, the smaller the incoming and outgoing ports can be made, which will result in better combustion conditions.

Types and Classes of Valves.

Valves may be of the following types: slide or damper, butterfly, mushroom and movable hood. They may be classed as dry, refractory-lined, water-cooled and water-sealed.

The slide and butterfly types may be any of the classes or combination of classes, but the water seal is rarely applied to them. The mushroom type may be of any of the classes. The movable hood type is usually refractory-lined and water-sealed, although the refractory lining is sometimes omitted. In a general way the

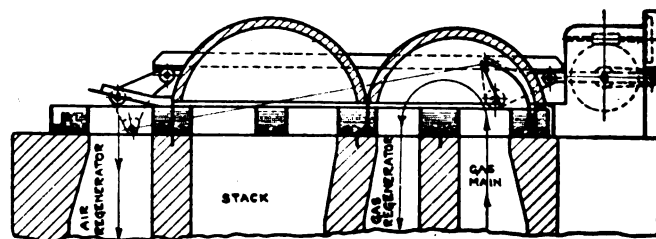


Fig. 3—The Isley valve.

butterfly valve may be considered as a modified slide or damper, and we can state that the slide valve, of all those devised, offers the least obstruction to the passage of the gas through it. Invariably, in the other types, a change of direction in the path of the gas of from 90 degrees to 180 degrees, and in some cases as much as 360 degrees, occurs, and the friction losses are therefore bound to occur.

In the dry class no attempt is made to cool the casting or plates of which the valve or its seat is made. The slide and butterfly are frequently of this character.

The refractory-lined valves are confined mostly to the slide, mushroom and movable hood types, although nearly all have the surrounding hood, where such is employed, lined with brick. Refractory linings are hard to

hold in place because of the jar that accompanies the reversal, and no matter how tightly wedged when put in service the lining will eventually loosen and fall out.

The water-cooled valves embrace the slide, butterfly and mushroom types. They have the principal parts, including the seat, filled with moving water, whereby an even temperature within the member is maintained and distortion from expansion and contraction prevented. They are not always reliable in this respect and are particularly likely to fail after a short time when made of cast iron.

About the year 1914, experiments were begun with a water-cooled damper valve made of rolled steel plate and at the present time it is possible to procure a welded steel plate valve working on an inclined water-cooled seat, each having machined surfaces where contact is made, that will give a minimum amount of leakage and is so

water and exposed water-cooled parts to one having a minimum amount of exposed cooling surface, resulted in an increase of temperature in the waste gases going to the boilers of approximately 180 degrees. This temperature difference checks up very well with the usual temperature drop found through the ordinary types of valves which offer a large amount of exposed cooling surface, and in one investigation I found the temperature to show a difference of 240 degrees. A similar change of valves at Wierton has resulted in their increasing the waste heat boiler output from 58 per cent to 78 per cent of rating. Wierton is getting this rating from their boilers on a low coal consumption, which, when their furnaces are working properly, is in the neighborhood of 450 pounds per ton of ingots.

Another objection to the use of a valve having a water-sealed seat has been that it is always liable to

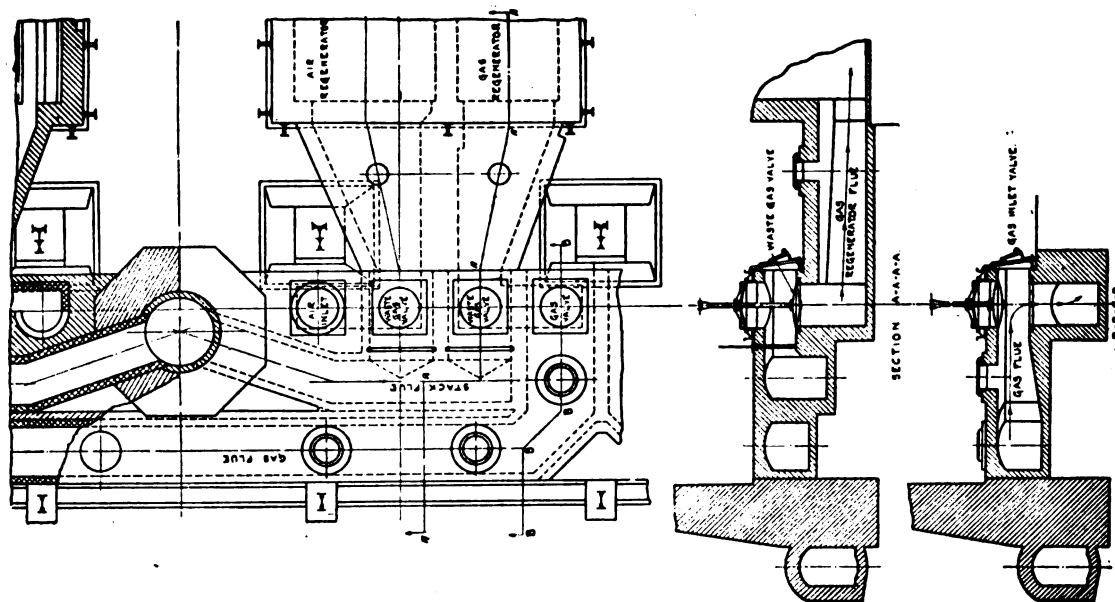


Fig. 4—Reversing valves and flue arrangement—Pennsylvania Steel Company, Steelton, Pa., 1910.

constructed that any expansion or contraction that might take place does not tend to distort the valve and destroy the seal. Some trouble was experienced with the accumulation of a carbonaceous material on the face of the valve which might tend to cause leakage, but with the present valve the trouble has been so slight that it is being given very little consideration. The adoption of a refractory surface, where the valve is exposed to the producer gas, will materially aid in eliminating any slight trouble that might be caused from this source.

Water-sealed valves provide the most perfect seal that has as yet been devised and can be used effectively with the mushroom or the movable hood. In each case a projection of the valve is plunged into a basin of water of sufficient depth so that the liquid column will more than balance the difference of pressure within the conduit and the atmosphere or adjacent passageway. The glaring fault of this class of valve lies in the water evaporation that takes place from the basin; the passing hot gas picks up the vapor and is cooled to an appreciable extent. There is also more or less water splashed into the gas flues at each reversal. This not only must be evaporated, but coming in contact with the brickwork of the flue causes deterioration. At the Gary works of the Illinois Steel Company, on some of their stationary producer gas furnaces, the change from a valve having exposed

leakage in portions that are hidden from the view of the furnacemen, and it is only when the effect upon the working of the furnace is noted that inspection, which in most cases is difficult, proves that the trouble is due to a crack in the casting, and it not infrequently happens that a negative pressure will cause a portion of the water to syphon from the basin into the flue. The substitution of welded steel plate seats for cast iron seats has to a great extent eliminated the trouble due to leakage, but the immersion of the valve into the water when the seal is made will remain a constant factor in the splashing of water over the edge of the seat and into the flues. The brick walls that form the flues and support the valve suffer from the effect of this moisture and the resultant weakening of the joints often causes leakage of gas from the gas passage into the waste gas flue, which often continues for a considerable length of time before becoming sufficiently bad to cause detection. The impact upon the seating of certain types of water-sealed valves is an added source of destruction to the seat, and not only do you have a serious loss, due to leakage of water into the flues, but in most cases it is necessary to stop the operation of the furnace until the seat can be replaced.

An added security is provided against gas leakage past the valve in one make in which the flues are completely separated by means of a brick-lined tube, acting

on the same principle as a switch in a railroad track, whereby the flues are connected as desired and the change in the flow of gas controlled. The water in connection with this valve is of comparatively small area, open to inspection at all times.

For moving valves every known method has been applied, including hand power, hydraulic, pneumatic and steam cylinders, and electric motor. The latter method is no doubt the most satisfactory, and its popularity will increase in the future. Whatever the mechanism employed, it should be of a sturdy character and able to withstand the strains that are put upon it.

The theoretical relation of the areas of gas and air valves and openings into the furnace has been discussed by numerous authors and for those who may be interested in this phase of the subject, reference is made to the paper on "The Principles of Open Hearth Furnace Design," by Charles H. F. Bagley,* and also to the paper on "The Basic Open Hearth Process," by Mr. F. H. Toy,† in which he states that practical experience has demonstrated that an air valve area of one square foot per ten tons of furnace capacity is adequate.

Much thought has been given to the development of

a satisfactory water-cooled valve and seat, and to one having a perfect seal, but it would appear that with the exception of two of recent invention, i. e., one in which one end of a section of flue swings through an arc of a circle connecting adjacent flues, and the welded steel damper type having an inclined water-cooled seat with machined working surfaces, none measure up to the requirements we have stated for an ideal valve. Too much weight should not be given in the choice of a valve to the first cost, providing satisfactory operating conditions in all respects can be attained.

The water-cooled slide with inclined seat comes nearest to the perfection we are seeking. Its durable mechanical construction, including sturdy manipulating devices, all of which is easily accessible for repairs, combined with straight line flue passages, least heat losses, independent control of flow for each chamber, minimum leakage, adaptability to local conditions, small space required, minimum loss of fuel at time of reversal and low maintenance cost, recommends it to our serious consideration.

*Journal of the Iron and Steel Institute, Vol. II, pp. 289-303.

†Year Book, American Iron & Steel Institute, 1920, pp. 319-362.

The General Effect of Electrification on The Operation of Steel Mills

Some Interesting Figures on the Operation of the Mills at the Mark Plant Are Included—Writer Believes Electric Power Is More Economical Than Steam Power.

By WILFRED SYKES

Assistant to the Operating Vice President, The Steel & Tube Company of America, Chicago, Ill.

THE reason for electrification is fundamentally due to certain inherent characteristics of the generation, distribution and utilization of electricity. Electrical generating stations use prime movers of the most economical type known today and of such size as to give the best operating results, independently of the size or characteristics required for any particular mill or other consumer of power. The combination of generating units in service depends only upon the combined load of all the mills that may be running and the available capacity can be varied rapidly to supply the demand for a greater or a lesser output and still maintain a high operating efficiency.

Frequently we have a choice as prime movers of either internal combustion engines, using blast furnace gas, or of steam turbines. The former, while having a better fuel economy, are limited by constructional difficulties to sizes of not larger than 3,000 to 4,000 hp, so that a large plant requires a great many individual generating units. The steam turbine can be built in any size that is required for even our largest plants and the limit of output of a single unit has not yet

been reached. The first cost of a gas engine driven station is at least twice as much as a modern steam station and this frequently is sufficient to offset the better economy. Continual improvements are being made in the design of steam stations which tend to reduce this difference in economy, and the situation today is that the difference in the number of heat units required in the fuel under average operating conditions probably does not exceed about 15 per cent. This is the overall efficiency from the fuel to the switchboard. The result of this freedom of choice of prime movers and the facility with which different combinations of machines can be run, to take care of varying operating conditions, makes possible a very much better utilization of the energy in the fuel than is possible with any type of prime mover driving the mill direct.

Another advantage of centralizing the power equipment is that, due to the diversity of the mill loads, the average that has to be carried by the central station is very much less than the summation of the loads that occur on the individual consuming units, and the fluctuations of load are less, so that the prime movers can be run at more nearly their most economical output.

The conversion of the output of the prime mover

*Abstract of paper presented before American Iron and Steel Institute, Spring Meeting, May 26, 1922, New York City.

into electricity is accomplished with a loss that seldom exceeds 5 per cent with modern equipment.

Perhaps the greatest economy of electric drive is due to the small loss with which this form of power can be distributed and the fact that the loss varies with the load so that the lines can be kept charged ready to supply power as demanded and loss only occurs when power is actually being used. Even at full load the loss in the lines seldom exceeds one or two per cent. If we contrast this with steam distribution, the saving is very obvious. Anyone interested in making up steam costs in a mill knows that, even after making what appears to be very liberal allowances for the consumption of the different engines based on the output of the mill, there remains a very large amount of steam not accounted for; and I think it would not be an overstatement to say that we can seldom account for more than about 50 per cent of the steam generated, consequently the difference must be prorated over the different mills. It is therefore very misleading to talk of any engine consuming so many pounds of steam per horse-power or per ton of steel rolled, unless we take into consideration this factor since what we are really interested in is the amount of fuel used as gas or coal to roll a ton of steel. This is a condition with which every mill engineer is familiar and even the best laid out and operated plants do not appear to be able to avoid it. With modern engine drives, quite good efficiencies are obtained under test conditions although, of course, not as good as can be gotten in a properly laid out central power station.

To convert the electrical energy to mechanical work we must use motors. The efficiency of a continuously running motor under the varying conditions of load will usually average well over 90 per cent. In the case of a reversing mill, which involves first the conversion of electricity from one form to another and then into mechanical work as well as providing for equalization of the peak loads, the overall efficiency from the switchboard to the mill coupling will run over 75 per cent.

In any discussion of economy we must be careful to distinguish between theoretical figures and actual operating results, as what we are interested in is the overall efficiency from the energy in our gas or coal to the mill coupling during a month's or a year's operation and the only teacher of any value is experience. The best measure is our power cost per ton of material shipped. Complete electrically driven mills show decided advantages when this measuring stick is applied to the question.

As a matter of interest, I am giving a few figures of two reversing mills in our plant, one being the reversing blooming mill and the other the reversing universal plate mill. The former rolls ingots (20 in. x 22 in., weighing 7,300 lbs.) to blooms averaging about 6 in. x 8 in. for the billet mill, and ingots (16 in. x 38 in., weighing 10,500 lbs.) to slabs for the plate mill. The plate mill rolls the slabs from the bloomer to skelp for the pipe mills, a typical range of which is given later in this paper.

Closely connected with the subject of economy is the question of mill layout. The facility with which electricity can be distributed relieves us of the necessity of considering power distribution and mills can be arranged in the best possible manner for operation without having to face any disabilities on the score of power economy.

POWER CONSUMPTION OF REVERSING MILLS, STEEL & TUBE COMPANY OF AMERICA FOR 1920

Kind of mill	Gross Tons of Ingots or Slabs Rolled	K.W. Hours per Ton, Main Drive Only	Power Cost per Ton, Main Drive Only
Blooming mill ..	444,510	16.2	17.8 cent
Plate mill	191,524	31.9	35.1 cents

Average coal cost per ton at boiler house during year = \$5.07.

Gas charged for at coal price on basis of equivalent evaporation.

To sum up, with a central station we manufacture our power wholesale and through a very cheap distributing system we deliver it to the consumer as required. If the mill does not require power, it does not have any losses to take care of. It is very much the same situation as exists in the commercial field. If we had poor distributing facilities for our commodities, it would be necessary to have a great many plants scattered over the country to take care of local demands, some of which would be busy and some idle with a consequent low average efficiency. As it is, we build a few plants in favorably situated localities and ship to the consuming points as required. We pay freight only as we ship. The demand of one locality frequently balances a lack of demand from another, so that our plant can be run at a good average load and efficiency.

The statement is sometimes made that electric drive is more expensive than a steam drive. I doubt very much if this is really so when a true comparison is made of all the factors that must be taken into consideration, such as boiler plants, steam distribution, water distribution, sewers and many other items that affect the total cost of the plant. Too frequently, in discussing this question, comparisons neglect important items which, while difficult to estimate, must be considered.

The rapid extension of steel-making and finishing capacity in recent years would indicate that in the immediate future the problem will be not so much extensions, as a rehabilitation of the older plants to enable them to operate with such efficiency as to be competitive, and this will require careful consideration of electrification as a means to this end.

Before leaving this phase of the subject, it is perhaps well to point out that the necessity of generating electricity for auxiliary purposes, regarding which no one questions the advantages, requires stations of substantial output. The following table illustrates this point and shows the power used for main drives and for auxiliary purposes at the Mark Plant during the year 1920. It will be seen that if the mills were driven by engines, a large proportion of the total power would have had to be electrical in any case.

Mill	Main Drive Only, K.W. Hours	Auxiliary Purposes, K.W. Hours
Blooming mill	7,061,000	5,040,000
Plate mill	6,111,000	2,967,000
Billet mill	2,920,000	1,890,000
Skelp mill	7,700,000	
	23,792,000	9,897,000
Total power generated	53,428,000 K.W. Hours	
Consumed, main drives	23,792,000 K.W. Hours	44½%
Consumed, mill auxiliaries....	9,997,000 K.W. Hours	18½%
Consumed, other parts of Steel and Coke Plant.....	19,639,000 K.W. Hours	37 %

Production.

Leaving the general characteristics of electrification I will endeavor to answer some of the more important questions that interest the executive and operator. The first question that is asked regarding any method of driving our mills is whether it will enable us to get the desired output? This is not only a question of the amount of power available but of the characteristics of the driving unit and the subject must be considered in relation to the different types of mills.

Continuously Running Mills.

In the case of a mill running continuously in one direction, there are practically only two points to be considered. The first is the power, the second is the speed characteristic. As far as power is concerned, any output required by our mills presents no unsolved problem to the motor designer. Very much larger motors than any individual mill is likely to need have already been built. I believe the highest rating of any machine driving a continuously running mill is that of the motor driving the 160 in. plate mill at Gary, Indiana. This motor is nominally rated at 7,000 hp, but to meet the particular specifications, it actually has a continuous capacity of about 9,000 hp. In operation this machine very frequently carries peak loads up to about 18,000 to 20,000 hp. The largest electric motor that has been built to date has a continuous rating of 22,500 hp or more than twice the capacity of the 160 in. plate mill motor and there is no particular reason why larger machines could not be constructed if there was any demand for them. As far as power is concerned, it is only a question of determining how large the motor should be. When we first started to electrify mills, very little data was available that would enable us to determine the proper characteristics. When it was attempted to translate indicator cards from existing engines into terms of motor output it was frequently lost sight of that the speed characteristics of engines and motors are very different and the indicated horsepower readings could be very deceptive, especially if the inter-relation of engine output, speed, and fly-wheel action were not carefully analyzed. Consequently, in the early days some mistakes were made, although on the whole it is surprising how few. Information that could be gathered from mills as to production was frequently fragmentary and it was early evident that if satisfactory results were to be obtained the electrical engineer would have to study mill operation and conduct such tests as would enable him to analyze the requirements. A great deal of work was necessary to enable this to be done, but real progress was not made until the manufacturer could tell the mill man that he could supply an equipment that would roll so many tons of finished material under defined conditions. This was something that was perfectly definite and subject to ready tests. It involved not only motor design but also cooperation between the electrical manufacturer and the purchaser on the subject of the type of connections between the motor and the mill, and the size of the fly-wheel and its location. Today, there are so many installations in operation and so much accumulated experience that the problem is comparatively simple and it is mainly a question of deciding the output required, keeping in view the possibilities of electric drive and of improvements of mills and auxiliaries which enable material to be handled more expeditiously. In this respect it is fortunate that the electric motor has a practically constant high efficiency over a very large range of load,

varying usually not more than $\frac{1}{2}$ to 1 per cent from one-half to full load, and also that the power station is so flexible that, if a machine is too large for the immediate requirements, the net effect on efficiency is practically negligible. It frequently happens that it is difficult to definitely specify operating conditions or that conditions will change after the mill has been installed and it has been my experience that it is wise to be liberal in choosing the size of motor, as the only disadvantage in doing so is a slight extra outlay which, in relation to the total mill cost, is trifling.

Regarding the speed characteristics, the ordinary motor tends to run at a practically constant speed independently of the load. Where a fly-wheel is used, the object is to assist the motor in carrying short time peak loads. For instance, in the case of a plate mill, the early passes may require four to five times the power of the motor for a fraction of a second. It can be arranged very readily that the motor will take a certain proportion and the fly-wheel supply the remainder. When the passes become longer, the peaks are reduced and the motor then carries a greater proportion of the load. By the proper inter-action of the motor and the fly-wheel, an economical balance is arrived at. The speed characteristics of the motor are usually varied by means of the control equipment and they can be readily adjusted to suit individual operating conditions. In the case of mills where the passes are long, the fly-wheels are of less value and it is frequently desirable that the speed remain practically constant, which is the inherent characteristic of the motor. We therefore have the possibility of either maintaining the speed constant within two or three per cent or of regulating it to give the best operating results, depending on the load condition. Sometimes the characteristic of constant speed enables us to obtain greater output as compared with an engine which usually does not hold its speed so well under heavy load; and in some cases that have come to my attention, it has been stated that the mills have an output of 5 to 10 per cent greater when electrically driven. In this connection it should not be lost sight of that the ordinary mill motor can carry double load for short periods without any particular sacrifice of efficiency or any great change of speed. Of course we want to run the mill as fast as the metal can be properly rolled and frequently the speed at which the metal can be entered into the rolls is the controlling feature, so it is obvious that the closer we can hold the average operating speed to this maximum, the greater will be the output.

Reversing Mills.

There has been more discussion regarding the motor driven reversing mill in comparison with the steam engine drive than of any other type and this is quite natural, as the motor is an invader in the field for which the engine seems to be particularly well adapted. Quickness of maneuvering and ease of speed control is of the utmost importance for a successful drive. This will be appreciated when it is realized what a comparatively small percentage of the time the metal is in the rolls. An analysis made of a number of steam and motor driven mills shows that in the case of a blooming mill operating rapidly, the metal is in the rolls about 30 to 40 per cent of the total time of rolling and from 60 to 70 per cent of the time is required to handle the steel. A casual observation of the mill does not reveal this, but it is surprising how closely well operated mills approximate to the same figures. There has been a good deal of discussion re-

garding the ability of the motor driven mill to turn out tonnage and if an analysis is not made of the operation, one can be readily deceived when observing steam and motor driven mills in operation. A motor driven mill appears to maneuver slowly but a closer observation shows that it is operated in a different way than the engine driven mill, due to the fact that its speed can be more accurately controlled. Observation of operation frequently leaves the impression that the motor driven mill is not doing much work, due to the absence of noise or other indications of action. Actual records, however, show that the motor can give a good account of itself. I am quoting a few figures from different mills which indicate the output that can be obtained in practice. I do not believe that these represent, in any way, the limits of a motor driven mill, as development is still taking place which enables the equipment to operate quicker and more efficiently, and I am sure that very much higher figures can be obtained than the ones I am quoting. I have not attempted to collect figures from all electrically driven reversing mills but am giving a few that have come to my attention. Possibly engineers from other plants that have electrically driven reversing mills have figures better than those I am quoting, but, at any rate, they will indicate what has been done.

At the plant of the Trumbull Steel Company, Warren, Ohio, there is installed a 36 in. blooming mill which rolls ingots 20 in. x 22 in., weighing 6,700 pounds to 6¾ in x 6¾ in. blooms in 13 passes. This mill has rolled 60 of these ingots in one hour and the operators feel that this figure can be improved.

Perhaps a better indication of the speed with which a motor can be handled is given by the machine driving the roughing stand of the 84 in. tandem plate mill of the Brier Hill Steel Company. The following figures show a 12-hour and 24-hour record. It will be seen that there is very little difference between the 12-hour and 24-hour figures:

ROLLING RECORDS OF THE 84 IN. TANDEM PLATE MILL OF THE BRIER HILL STEEL CO.

	12 Hours	24 Hours
Number of slabs.....	1,659	3,270
Number of passes in roughing mill.....	7	...
Total charged weight, tons.....	373	716
Total finished weight, tons.....	315	518
Maximum number of slabs for one hour..	220	...
Finished tons of 10, 11, 12 and 14 gauge U. S. Standard.....	23	71
Finished tons of 8 and 9 gauge.....	13	435
Finished tons of 3/16 inch, No. 10 gauge..	26	6
Finished tons of ¼ inch and heavier.....	253	6

It will be seen that this mill averages, over a 12-hour period, about 16 passes a minute or less than 4 seconds per pass, which takes in all delays due to any cause. This mill has been in operation since September, 1919, and the performance has progressively improved as the men became familiar with the best methods of operation.

A third illustration, taken at our own plant, is that of our universal plate mill which has rolls 30 in. in diameter and can roll universal plate up to about 46 in. wide. It is used for rolling skelp for our pipe mills and the material is, on an average, small for this size of mill. During the month of March, 1920, this mill turned out 23,014 gross tons of material and, as a matter of interest, I am giving details of how this was made up, from which it will be seen that the gauge was fairly light and the width not the best to secure maximum tonnage.

UNIVERSAL PLATE MILL PRODUCTION, MARCH, 1920

— Sizes Rolled —					
Width Inches	Thick- ness, Inches	Length Feet	Product Gross Tons	Slab Sizes, Inches	Slab Weights, Pounds
12	.375	Various	12	11¼x4	Various
15	.250	18'-19'	1,598	15 x4½	1,480-1,240
15	.360	18'-19'	72	15 x5½	1,790-1,440
18½	.310	18'-19'	510	18¾x5½	2,270-1,905
18½	.385	18'-19'	145	18¾x6	2,480-1,990
22	.290	19'-20'	1,003	22¼x5½	2,650-2,220
22	.437	18' 6"-19'	25	22¼x5½	2,630-1,975
22¼	.255	19'-19' 6"	174	22½x5	2,320-1,940
23½	.245	19'-20'	288	23¼x4½	2,390-2,000
23½	.285	19'-20'	2,816	23¼x5½	2,780-2,340
23½	.345	19'-20'	4,149	23¼x5½	2,820-2,270
25	.465	18' 6"-19'	25	25½x6	3,165-2,385
28¾	.285	19'-20'	953	29¼x4½	2,850-2,290
28¾	.290	19'-20'	774	29¼x4½	2,900-2,325
28¾	.295	19'-19' 6"	125	29¼x4½	2,920-2,350
28¾	.320	19'-20'	3,302	29¼x5	3,210-2,600
28¾	.330	19'-20'	1,038	29¼x5	3,280-2,630
28¾	.365	19'-20'	931	29¼x4½	2,925-2,210
28¾	.437	9'-11¾"	27	28¾x5	3,110-2,660
28½	.585	18'-18' 6"	132	29 x5½	3,330-2,190
32¾	.375	Various	74	33¼x5	Various
35½	.290	19'-20'	872	36½x5½	4,280-3,580
35½	.320	19'-20'	1,056	36½x4½	3,180-2,390
35½	.360	19'-20'	1,837	36½x5½	4,380-3,580
35½	.365	19'-20'	319	36½x5½	4,380-3,580
35½	.450	19'-20'	506	36½x5½	4,500-3,430
42¾	.345	19'-20'	251	36x5-44½	2,160

Total gross tons rolled.....23,014

Total hours worked.....648

Total hours delay.....79

Actual hours worked.....569

Total slabs rolled.....21,100

Good product94.00 Per Cent.

Maximum day1,101 Gross Tons

Minimum day732 Gross Tons

It will also be seen that the delays were appreciable, which was due to the necessity of waiting for steel at times, roll changing, and minor troubles. We do not feel that this represents the limit of capacity of this mill and if necessary it could probably be boosted up to close to 30,000 tons per month by the addition of more heating furnace capacity and perhaps the elimination of some of the sizes which are entirely too small for a mill of this size.

These examples will give an indication of what is actually being done with the reversing mills that have already been installed. It has been my experience that factors outside of type of drive have in general limited tonnage. Much greater outputs can be obtained if necessary.

Delays.

If we are satisfied with the possibility of rolling a desired tonnage, the next question is whether the equipment will operate continuously or at least with no more delay than encountered with steam drive. Here again the best answer is experience and in the following I am quoting figures from one or two mills which show the actual results obtained. The first electrically driven reversing drive to be installed in the United States was that of the 30 in. universal plate mill in the South Chicago Plant of the Illinois Steel Company, which was put in operation in 1907. It was designed about the same time as the first equipment in Europe and went into operation a few months later. It must be appreciated that the electrical engineer was attempting to solve an entirely new problem with very little data and no experience, and later developments have shown that many of its constructional

details could be materially improved. However, the history of this pioneer installation is of interest as it illustrates that even with an entirely new problem the time lost due to changes or breakdowns has not been serious. The major delays of this mill have been as follows:

November 10, 1907—Mill shut down for one week to correct armature cross connections.

October 14, 1908—Mill shut down to try out spare generator armature which had been purchased.

September 12, 1909—Change of generator armature due to grounded coils.

October 24, 1909—Generator armature changed due to some bars becoming unsoldered.

A novel design of generator was tried out in this installation which has not been used in subsequent jobs; this accounts for the particular troubles that caused the above delays. In 1911 there was a delay of a few hours caused by a slight short circuit on the commutator of one of the roll motors and in 1913 the mill was down for approximately 72 hours due to a grounded motor coil. In 1917 the generator armature was changed on account of a ground. The total of all delays, including those occurring during the development period, is approximately 525 hours out of about 100,000 hours that this mill has been operating, which I think is very creditable when it is borne in mind that it was a pioneer installation and was built at the time when the electrical engineer had not had the experience in building large equipments for steel mills that he has today. It might be mentioned that in 1920, after this mill had been in operation 13 years, no delays were charged against the drive, although the mill rolled in this year 20 per cent more than in any other year in the first ten years of its life.

In March, 1913, The Steel Company of Canada put in operation a 34 in. electrically driven blooming mill. This equipment embodied a number of important changes from the general design used for the Illinois Steel Company's mill and some control features which at that time were novel. A few days were lost, when the mill was first started up, in making a number of changes in the control. No particular effort was made to save time, as at that period the output of the mill was not urgently required. During the last six years the total delay charged by the blooming mill department against this equipment has been about 12 hours and a detailed analysis of these figures shows that only about two hours have been due to delays caused by the equipment itself being down for any reason. These delays were made up of a few minutes at a time required to change a contact on a switch or some such minor matter, the remainder of the time lost was due to such causes as interrupted power supply, etc.

Another example is the 35 in. blooming mill at Mark Plant. This mill was put in operation in April, 1918, and has run continuously to date. The total delay charged to the equipment is about 12 hours, the major part of this being due to interruption of power supply, which occurred when sand got into the boiler feed pumps and made it necessary to cut down station output until the difficulty could be corrected. Only a small part of the delays have really been due to the inability of the drive to operate the mill, perhaps not more than an hour or so. Such times that the mill has had to be shut down for electrical troubles have been made up of periods of a few minutes at a time

for correction of minor difficulties involving adjustment of control equipment.

The examples I have cited I think are typical of what can be expected with reasonable operation and if accidents do not occur. Of course in the development of such equipments troubles have occurred which have been eliminated in later designs. Most of these troubles have been of a minor nature and the tendency has been towards simplification and so arranging the layout that an oversight or carelessness on the part of the attendants would not cause serious difficulties. However, accidents will happen in all plants and as an illustration I might mention some troubles we had with our plate mill drive. On one occasion it was found that the blowing equipment, upon which the cooling of the reversing motor depends, was not operating. This was not discovered until the motor had become very hot, so hot in fact that the solder from some of the connections flowed. In later equipments, by simple means, provision has been made so that the motor cannot be operated if the blower is not delivering air to it. Nothing occurred immediately following this overheating, but about a year later one of the armature coils broke down and an examination of the machine showed that the insulation had been seriously injured by overheating. Temporary repairs were made which caused a delay of about 24 hours but a few weeks later another armature coil failed and it was decided that it would be wise to shut the mill down long enough to entirely rewind the armature, as it was felt that the winding had been so injured that more or less trouble could be expected from it, if this was not done. The motor was therefore put out of service and the armature completely rewound, the time required for the different operations being as follows:

Disconnecting from the mill and removing armature from motor.....	12 hours
Stripping old coils and preparation for rewinding...	34 hours
Rewinding	50 hours
Reassembling the machine.....	16 hours
Drying, varnishing and baking the armature.....	96 hours
Total.....	208 hours

As a precautionary measure it was decided not to start the machine until it had been thoroughly dried out and we were sure it was in as good condition as when originally installed. Facilities for drying and baking the armature, such as manufacturers have, were not available and it was necessary to experiment somewhat to find out the best way to do this. At least 60 hours could be saved, if such a mishap occurred again. If a spare armature had been available, the delay would not have exceeded 24 hours. This represents about as serious a failure as is likely to occur and I am giving its history so that some idea can be formed of what a really bad breakdown of such an equipment means in the way of delay.

Operating Labor.

A factor in which our operators are particularly interested is operating labor. Most mills feel that their larger and more important drives, such as reversing mills, should have an attendant present to watch them, mainly as a precautionary measure. In the case of continuously running mills, there has been enough experience to show that this is not necessary and now it is customary for one man to inspect a number of machines and to take the usual meter readings for the mill records. When an operator is employed continuously to look after a drive, the usual practice is to put

substation equipment under his control, as it is generally convenient to install converting apparatus in proximity to the main drive. These men have very little to do outside of occasionally looking over the machines and taking meter readings. The actual work in attending to a reversing blooming mill drive, for instance, I do not believe would exceed one hour per day. At the Mark Plant the blooming mill has been charged, for the years 1918, 1919, 1920 and 1921, an average of \$393.00 per month. In the case of the reversing mill of The Steel Company of Canada, from 1913 to 1919, the average has been about \$250.00 per month. The difference is mainly due to the fact that the figures for the former cover the period of highest wages in the mills.

Maintenance and Repairs.

Electrical machinery requires maintenance as well as any other equipment. With intelligent electrical superintendents most of the expenditure is of a precautionary nature and repairs due to breakdowns become a very small item. As an illustration of the maintenance and repairs on reversing drives, the experience of The Steel and Tube Company of America can be cited. For the four years, 1918, 1919, 1920 and 1921, the maintenance and repairs for the reversing blooming mill drive averaged \$184.00 per year. In the case of the reversing plate mill drive previously referred to, the ordinary maintenance and repairs have averaged about \$173.00 per year and the expenses in connection with the failure and complete rewinding of the armature totaled about \$6,530.00. The maintenance of the blooming mill of The Steel Company of Canada has averaged since it was installed, for all purposes, about \$1,280.00 per year. This higher cost compared with that at the Mark Plant is due mainly to the smaller size of the plant and a part of the difference may be ascribed to improved design of the later equipment. The supplies for operating these two blooming mills have averaged in each plant about \$50.00 per month. These figures give an idea of what can be expected in the case of reversing mills. In the case of continuously running mills, the expenditures vary considerably, some mills paying practically no attention to their equipment and others carefully clean and revarnish their machines at intervals. In going over the figures of plants where freedom from breakdown is characteristic, it would seem that for motors from 2,000 to 3,000 hp we should spend perhaps \$200.00 to \$250.00 per year to keep them in condition. The cost will vary somewhat with the number of equipments the force has to look after, as with a larger plant the cost per machine will average less than in a smaller mill. Before leaving this phase of the subject I would like to quote a statement of the electrical engineer of the Illinois Steel Company regarding the physical condition of their reversing mill which, as previously stated, has been in operation since 1907. The commutators of the reversing motors show about 1/16 in. wear and the commutators of the generators show a wear of about 1/16 in. for each five years of service. This would indicate a life for the commutator of the motor of about 180 years and for the generator about 60 years. The windings are in apparently about as good a condition as when first installed. At the end of 10 years some wear of the motor generator bearings was noticeable and as an insurance, spares were purchased, but to date have not been installed, as in the last five years there has been no appreciable wear. The original motor bearings are in use and apparently will

last indefinitely. Another example illustrative of the long life of electrical equipment when given good care which came to my notice, is the case of the 2,000 hp motors driving the light rail mill at South Chicago, Illinois. These machines were installed in 1906 and after about 14 years of service the Steel Company thought that perhaps it would be a good precaution to rewind them. A careful inspection by the manufacturer revealed no apparent deterioration and the recommendation was not to disturb them. These experiences indicate what can be expected with carefully operated plants.

In the foregoing I have given a few examples that will indicate to those whose duties do not bring them in close contact with electrical equipment what can be expected. It should be borne in mind that manufacturers have profited by their accumulated experience and many possible sources of troubles have been eliminated in recent installations. Another factor that will tend to secure even better results in the future is that a body of intelligent electrical engineers and attendants has been built up by our technical and trade schools, as well as by the principal manufacturers, from which our mills can draw good men. The electrician of the early development period was often very expert in making repairs but did little to avoid them. Today men are available who have been trained to avoid troubles.

Due to the many ways in which power problems can be solved electrically it is natural that frequently a difference of opinion exists as to the best way to handle particular requirements. In many of the cases, either one of a number of schemes will give entire satisfaction. In other cases, perhaps there is a best scheme, but other layouts are capable of satisfactory operation although not inherently as good as the best. In the following I am endeavoring to make what seems to me to be a fair statement as to the present state of the art, which might perhaps act as a guide to those having to make decisions on equipments and who are not familiar with engineering details. I am not attempting to give the reasons for these statements as it would lead into too long a controversial paper.

Power Equipment.

In building a modern plant we have the choice, in most localities, of either purchasing power from a Public Utilities Company or of building our own power plant. When we have sources of heat that would otherwise be wasted, this is usually sufficient reason for building our own plant. Public utilities, however, in many cases can make rates and give assurance of continuity of supply which make their power attractive.

Any modern power plant would only be built with alternating current units, as direct current involves too much expense for the distribution of large powers and has limitations from a generating standpoint.

In general, we have a choice of two pressures, 2,200 volts or 6,000 volts, either of which can be used directly with motors for main drive. Experience has shown that if the distribution problems are not too serious, 2,200 volts should be chosen, as the machines for this pressure are much freer from insulation troubles than those for 6,600 volts.

There are two frequencies in use in the United States, 25-cycle and 60-cycle. In the early days of electrification, when it was thought that most generators in the mills would be driven by gas engines and that the motors would be directly connected to the

rolls, the 25-cycle system seemed to be the logical one to adopt. At that time, the means of connecting the higher speed motors to mills were not very satisfactory. Since then gearing and other mechanical features have been very materially improved, so that the great majority of mills installed today use moderate speed motors geared down to the mill speed. The 60-cycle system has grown rapidly in favor during recent years and for main roll drive with proper connections is quite as satisfactory as the 25-cycle system. A further advantage is that the large power systems, which are gradually spreading over the country, are practically all 60-cycle and it is probable that in the future mills will find it profitable and desirable to purchase at least some of the power used. The 60-cycle system has a number of advantages as a greater range of motor speeds is obtainable and the machines are lighter and cheaper. The perfection of 60-cycle converting equipment, which was not available a few years ago, has materially changed the situation. The type of prime mover has an influence on the frequency adopted. Practically all gas engine driven units of the large size have been built for 25 cycles and there are some difficulties in the way of building 60-cycle units.

The choice of prime mover must be decided greatly by local conditions. In the early days the tendency was to use gas engines. The tendency today, however, is to use steam turbines and, as previously mentioned, improvements that are continually being made are reducing the difference in fuel economy between the two types. The first cost is an important item and one which seriously affects real economy.

To sum up, for the ordinary sized plant, the general practice today is to build a turbine station, generating current at 2,200 volts, 60 cycles, which is distributed direct to the mills.

Distribution.

In the older plants most of the distribution is overhead. This is somewhat cheaper in first cost than the other alternative of placing all our cables underground, but it is not nearly as satisfactory. The best system is to use insulated lead covered cables laid in ducts embedded in conduit which run to the different consuming or distributing points. A great many of these ducts can be grouped together to run in such a way as not to interfere with any of the other parts of the plant. This leaves our yards entirely free from overhead obstructions. The use of overhead lines is always attended with danger, not only to life but also from an operating standpoint, as frequently the lines are damaged or torn down when running locomotive cranes around the plants. The use of an underground system eliminates all danger from lightning disturbances. The high tension underground distribution system at Mark Plant has not had a single failure in five years of operation.

Substation Equipment.

We have the choice of either motor generator sets or rotary converters. The tendency is to use rotary converters, as they are lower in first cost and much more efficient. Motor generator sets give us the possibility of using substation equipment to improve power factor and in some cases they are justified. In a new electrification scheme, however, with proper design rotary converters are on the whole entirely satisfactory. It would seem that the greater loss in

the motor generator set is an expensive way of improving power factor.

The development of automatic or semi-automatic control of substation equipment materially affects the question of substation layout and location. It is now quite feasible to control all our substations from the power house and the equipment is such that the only attention required is that which can be given by the motor inspector employed in the particular department where the apparatus is installed. This so reduces operating expense that we can afford to have more substations and save on our distributing copper. The freedom of layout gained thereby is a decided advantage.

Drives for Reversing Mills.

There is only one practical system to use. It requires a fly-wheel motor generator set for supplying power to a direct current reversing motor connected to the rolls, and it is not likely that this scheme will be changed by future developments. Details of the machines vary somewhat with different manufacturers and it is only necessary to point out that very substantial mechanical construction is necessary on account of the shocks to which the machines are subjected. Reducing the cost by light construction is not justified. The control equipment is very important and the manufacturers have used a variety of schemes. There is more than one way of solving the problem, but the final result should be that skill on the part of the operator is not necessary. It should be possible for the operator to simply throw his control handle from one position to another and for the equipment to automatically perform the desired result immediately in such a way that the machines are not distressed. If the machine can carry a certain load safely, the automatic controlling equipment should be so arranged that during each manipulation the machine is loaded to its safe operating capacity but no higher. The nearer this ideal can be approached, the better the control equipment. The control equipment should also be such that it can be set to limit the load on the power house to any predetermined figure and to always operate at this point. To have a really satisfactory equipment it is necessary to closely approach this ideal and the best equipment is one that does it with the simplest apparatus. Improvements in the future will probably be towards making the machines cheaper due to better design, but the main development will be towards simplifying and improving the control equipment to give an operation approaching the ideal as nearly as possible. Reversing mill equipments as made by the two principal manufacturers, have proved adequate and reliable. Provision should be made in the layout to insure that the machines are properly ventilated at all times and a failure of the air supply should shut down the equipment before it can be injured. The electrical design is in general best left to the manufacturer. For instance, whether single or double armature motors are used is immaterial unless it involves a machine of more than usual voltage. When the power required is greater than can be supplied by a single generator fly-wheel set, the tendency is to run two generators in series on one motor. If this involves using a total armature voltage of 1,000 to 1,500, it is preferable to use two motors and connect all the machines in series which, if they are arranged alternately, generator and motor will limit the voltage at any point to that of one generator only.

Calumet Steel Company Electrify Mills

Rotary Converter Adjustable Speed Sets as Applied to a Rail Re-Rolling Mill—Twelve Stands of Rolls Are Now Electrically Driven.

By L. H. HOOK and F. R. BURT

THIS paper deals with the electrification of the rolling mills of the Calumet Steel Company at Chicago Heights. Installation was completed, and the equipment put into operation approximately a year ago. The mills electrified are an 8 in. five-stand mill, and a 14 in. seven-stand mill.

The 8 in. mill was formerly driven by an 18 in. x 30 in., 120 to 150 rpm, simple non-condensing steam engine, through 17 1 in. ropes. The pulley ratio was 108 in. to 48 in., giving a mill speed of 270 to 337 rpm. A 14-ton, 11 ft. diameter fly-wheel was mounted on the engine shaft. This mill is of the simple merchant type, and is used for rolling small orders of varied product which cannot be produced economically on the 14 in. mill.

The 14 in. mill was designed for re-rolling rails into concrete reinforcing bar, tubes for fence posts and bedsteads, small structural shapes, etc. It consists of a seven-stand train, split into two drives. Five stands are driven from one end, and two stands with two additional stands of forming rolls from the other. The forming rolls are set in tandem after the bull head, and are driven by gears from the main shaft. They are used for shaping tubes, and require only a small amount of power.

A continuous furnace fired with powdered coal heats the rails, which are broken into convenient lengths before charging. An approach table with continuously running rollers leads from the furnace to the splitter, which is the fifth stand in on the five-stand drive. The first pass, which is taken between the middle and top roll, slits off the flange, which is then finished into tubing or small structural shapes on the two-stand drive. The second pass on the splitters, separates the web and the head, which are both finished on the five-stand drive. When finished, the bars are run out on separate cooling beds, and thence to the shears, straighteners, and to the Shipping Department.

This mill was formerly driven by two duplicate 26 in. x 48 in., 80 to 95 rpm, simple non-condensing steam engines, by means of 16 1½ in. ropes. The corresponding mill speeds were 160 to 190 rpm.

To supply the mill engines with steam, it was necessary to keep in service one 600 hp, and four 250 hp boilers, and the cost of attendance for the five boilers and three engines was necessarily large. At the time this mill was built, much lighter steel was used by the railroads than at present, and although the engines were large enough at that time, they were found wanting when 90 and 100 lb. rails began to appear as scrap,

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Mr. Hook is works manager, Calumet Steel Company. Mr. Burt is general engineer, Westinghouse Electric & Manufacturing Company.

and also as the tonnage produced increased through more efficient methods. On the heavier schedules, the engines all slowed down considerably under load, and it was impossible to handle all the tonnage which the mills themselves would have been capable of turning out had they been supplied with sufficient power.

In electrifying the 8 in. mill, it was decided from past experience with the steam drive, that adjustable speed was not required, and a constant speed, 292 rpm motor of 500 hp capacity was installed, direct connected to the mill through a flexible coupling. The control for this motor is of the magnetic secondary type, with a hand operated double throw primary circuit breaker. This breaker is operated from a panel located

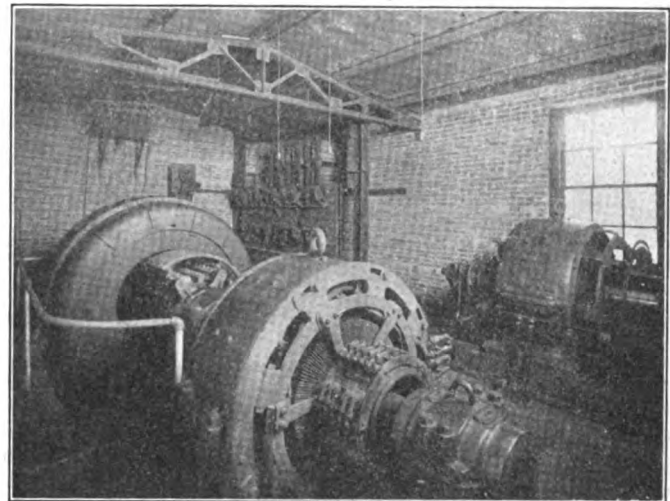


Fig. 1—14-in. mill motor room, showing 1,000-hp. adjustable speed set and control.

near the mill, and the drive is started and stopped, or plugged when necessary by the roller or other authorized mill man.

With the electric drive, the tonnage on this mill has been markedly increased, having been almost doubled on certain schedules. In 384 hours' operation, delays of 71 minutes have been charged to the electrical equipment. This is .3 of one per cent, based on the operating time. The first few weeks of operation are always the most trying for an electric drive. After the equipment has been in operation for some time, the various parts adjust themselves to each other, the bearings get worn in, the operators get acquainted with the machinery and learn how to handle it to the best advantage. It has been found on correctly applied electric drives that although the delays may be appreciable during this period, they become negligible later on.

The steam engines on the 14 in. mill were replaced

by two duplicate 1,000 hp rotary converter adjustable speed sets of the constant horsepower type. It was thought advisable to have more speed adjustment than could be obtained from the steam drive, and accordingly these sets were designed for speeds of 450 to 590 rpm. Each is connected to the mill through a flexible coupling and a herringbone gear unit, specially designed with a short center distance between gear and pinion shafts. The reduction is 3.1—1 giving a mill speed of 145 to 190 rpm.

Each of these electric drives consists of a main wound rotor induction motor, a smaller direct current

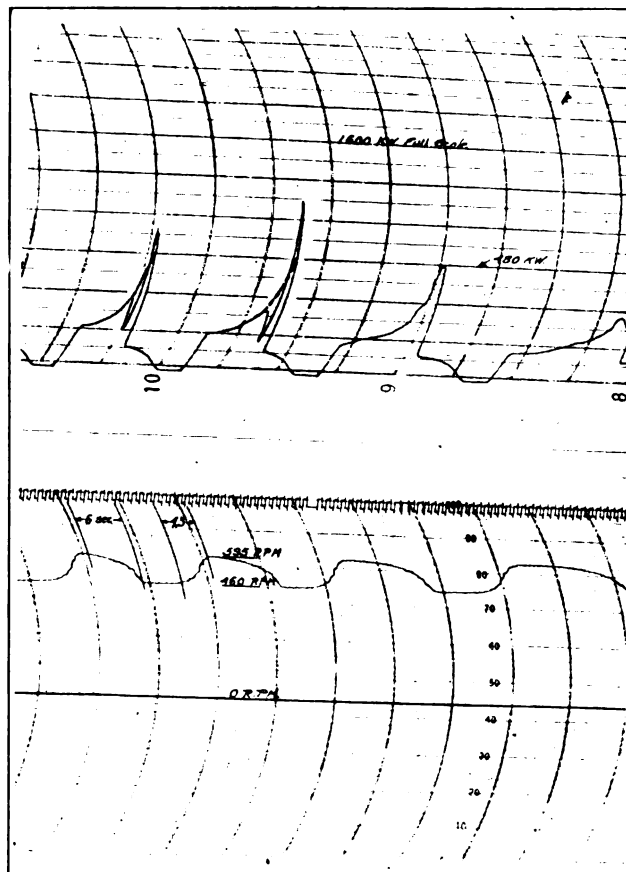


Fig. 2—Charts showing time required to change speed.

motor direct connected to it, and a rotary converter.

In any scheme for securing adjustable speed on induction motors, one of the auxiliary machines must be mounted on the same shaft if the advantages of constant horsepower throughout the speed range are to be obtained. An induction motor in itself is essentially a constant torque machine—that is, with a given current in the windings, the same torque will be exerted at all times, regardless of the speed. An induction motor exerts torque by virtue of the interaction of the current in the secondary and the flux set up by the primary. To circulate current in the secondary, there must be a voltage generated, and this voltage is produced by a difference in speed between the rotating field in the primary and the mechanical rotation of the conductors of the rotor. The voltage generated is directly proportional to this difference in speed or "slip." If it were possible to operate an induction motor at exactly synchronous speed, there would be no voltage in the secondary, consequently no current could flow, and the motor would produce no torque.

If a load were thrown on this motor, it would not be able to carry it, and would immediately start to slow down. This slowing down would cause a difference in relative speed of flux and conductors, which would generate a voltage in the secondary. This voltage would circulate current, and the motor would immediately begin to exert torque. At some certain point during this slowing down process, a point is reached where the torque exerted by the motor is just enough to carry the load, and the motor operates at this speed until the load is again changed. The design of a good rolling mill motor, with short-circuited secondary, is such that a drop in speed of approximately $1\frac{1}{2}$ or 2 per cent is sufficient to allow it to carry full load torque.

If a voltage is introduced into the secondary circuit which opposes the voltage generated by the slip, the motor must slow down to a point where the latter predominates by an amount sufficient to allow the motor to carry the load. For instance, if the locked secondary voltage of a motor is 1,000, and it drops 2 per cent in speed at full load, it indicates that 20 volts are required in the secondary to allow full load current to circulate. If now a counter voltage of 180 volts is impressed, the motor must generate 200 volts, or must drop 20 per cent in speed. The result is the same whether this counter-voltage is obtained from an external source, or whether it is due to resistance in the circuit. A resistance drop may be considered as a counter-voltage, since it absorbs a portion of the generated voltage. Any desired speed from full speed down to stand-still can be obtained by inserting the proper amount of resistance in the rotor circuit, but this speed with a given amount of resistance can be obtained only at one value of load, since at any other load, the rotor current, and therefore, the counter-voltage of IR drop are different. In other words, resistance in the secondary circuit simply exaggerates the natural speed characteristic of the motor, which varies from full load speed to synchronous speed, depending on the load. Since the induction motor delivers the same torque with a given rotor current, independent of the speed, it follows that the horsepower is directly proportional to the speed. The horsepower input from the line is constant, and the difference between the input and output, except for the internal losses in the motor, appears at the rotor slip rings. If the speed reduction is secured by means of secondary resistance, this energy is dissipated in the form of heat and is lost.

In order to obtain definite speeds which will not vary under changes of load, it is necessary to keep the counter-voltage constant by taking it from an external source, and this voltage must at all times be the same in frequency and phase position as that generated by the rotor, if the system is to be operative.

Hence, there are three prime requisites for a successful and economical alternating current, adjustable speed equipment:

- (a) An easily controlled voltage must be impressed on the rotor.
- (b) This voltage must be of the proper frequency and phase displacement.
- (c) The energy in the secondary due to the slip must be conserved.

All ac adjustable speed sets are designed with these three objects in view, although they may differ in the type of auxiliary machines used, and in the use made

of the slip energy. There are two main classes of sets. One delivers constant torque throughout the speed range, and the other delivers constant horsepower. An equipment of the former class feeds the slip energy back into the line, simply circulating this amount of power through the machines. Equipment of the constant horsepower type delivers the slip energy back to the shaft, increasing the torque in proportion to the speed reduction. The machines at the Calumet Steel plant are of the latter type.

On each set, the main 1,000 hp induction motor delivers $\frac{450}{590} \times 1,000$ or 763 horsepower at the low speed. The input at all speeds corresponds to 1,000 hp output. The difference between the input and output, in this case 237 hp, appears at the slip rings, and is transferred through the rotary converter, where it is converted to direct current and impressed on the direct current motor. The direct current motor changes it to mechanical energy, increasing the torque on the shaft and bringing the total output up to 1,000 hp. On this mill, small rails designated as 4 in. or less,

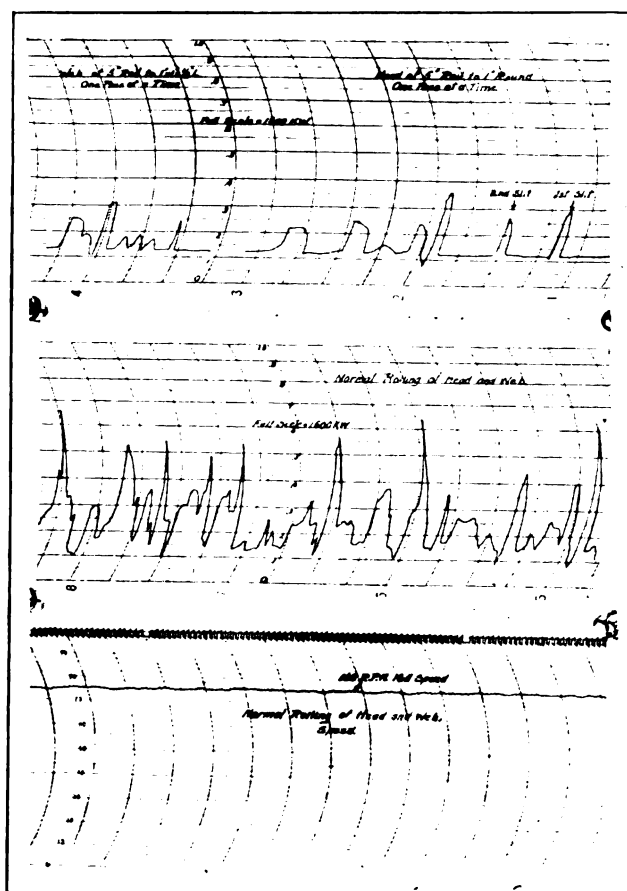


Fig. 3—Power required on five stand drive.

are rolled at the high speed, while the slow speed is used for the largest rails. Rolling from 5 and 5¼ inch rails requires considerably more power than reducing the smaller sizes, hence the constant horsepower drive fits in admirably on this type of mill.

The starting and speed adjustment of these drives, are accomplished from the master switch, and a rheostat control switch. With the master switch in the "off" position the primary and secondary circuits of the main motor, the direct current circuit between

rotary and direct current motor, and the field circuit leading to the rotary and direct current motor, are open. Moving the master switch to the first position closes the contactors which connect the secondary of the main motor to the starting resistance, provided the direct current motor field rheostat is in the "off" position, and the speed limit device on the rotary converter is set. The second point on the master switch closes the primary contactor, which, in turn, releases the first accelerating relay in the secondary circuit. The motor now comes up to speed, the secondary contactors which short-circuit the resistance being controlled by current limit relays, so that the current is maintained between predetermined limits during acceleration. The operation at this point is that of an induction motor with short-circuited collector rings, and if it is desired at the high speed, the master switch is left on the second point. The rotary is connected to neither of the other machines, and the field circuits are open. If it is desired to operate at reduced speed, the master is moved to the fourth point. The third point closes the field circuit to the direct current motor, whose rheostat is in the "off" position, and to the rotary converter whose rheostat is set for normal field current. The fourth point disconnects the secondary circuit of the main induction motor from the resistance, which is now short-circuited, and connects it to the slip rings of the rotary converter. The regulating circuit is now completed, but since there is no counter-voltage being generated, the only effect on the speed is that of the very small resistance introduced in the rotor circuit by the other machines. The main induction motor is rotating at nearly synchronous speed, and therefore, is generating practically no secondary voltage. The direct current motor, although running at full speed, has its field unexcited, and therefore, is delivering only a very small voltage, depending on its residual magnetism. The rotary converter, although its field is fully excited, has very little voltage across its terminals, and therefore, is at a stand-still, or very nearly so. However, if a field is now put on the direct current motor by moving the control switch which operates the motor-operated field rheostat, a voltage is generated which is impressed on the rotary converter, and through it on the secondary of the main motor. The machines are so connected that this voltage opposes that of the rotor, which must slow down and increase its slip voltage. When the latter becomes enough more than the impressed voltage to allow a current corresponding to the torque to flow, a point of equilibrium is reached, and the set operates continuously at this speed, with small variations under load, until the setting is again changed. Any speed within the range can be obtained by manipulating the rheostat control switch. If in case of emergency, it is desired to stop quickly, the master switch and control switch are brought to the "off" position and the master moved to "reverse." This impresses full voltage on the primary in the reverse direction and brings the motor quickly to rest.

A pulpit over one end of the mill contains the master switches and speed control switches for both sets, and also an operator's panel. On this panel there are mounted indicating wattmeters showing the input to both drives, and a voltmeter and ammeter in each direct current circuit. A system of signal lights indicates to the operator the position of the main incoming line circuit breaker for the plant, the hand operated circuit breaker for each set, and the electrically oper-

ated primary reversing contactors, all of which are located in the sub-station, and also of the principal contactors in the secondary circuit, which are located in the motor rooms. This control apparatus could have been mounted on the mill floor and operated by the roller, but it was considered that the time saved by having an operator on the job who had no other responsibilities would more than pay his wages.

The rapidity with which the speed of these sets can be changed, and their stability under such conditions are shown in Fig. 2. The upper chart is kilowatts input and the lower is revolutions per minute. The zig-zag line on the upper margin of the lower chart represents time in seconds. In taking these readings, the field rheostat was turned by hand as rapidly as possible from one maximum position to the other. It will be observed that the speed was increased from minimum to maximum in 6 seconds with an input of 480 kilowatts, and that it was decreased from maximum to minimum in 4.3 seconds. The regenerative power during this operation is not indicated, as the pointer was against the stop on the meter. When these sets were put into operation, the three-point rheostats in the direct current motor fields were improperly connected, due to an error in the wiring diagram. This caused a section of resistance in one of the rheostats to burn out during the try-out while steel was in the mill. The operator, observing that the mill had come up to high speed, moved his speed control lever back and forth several times. Each time the rheostat arm moved across the open spot, full field was alternately put on and taken off the motor. Notwithstanding the fact that the set was loaded, it responded to these almost instantaneous changes of conditions with no signs of distress or instability.

Power for operating these drives is supplied by the local power company, the Public Service Company of Northern Illinois. It is brought into the substation on the property at 4,000 volts, which is the voltage used on the motors. In the substation are the main incoming line circuit breaker, the feeder breakers for the three mills, the "forward" and "reverse" primary contactors for the 14 in. mill drives, switching and transforming apparatus for the low voltage mill circuit, and a small exciter set, which supplies dc excitation for the sets.

The first chart on Fig. 3 shows the kilowatts input to the five-stand drive when rolling the head of a 5 in. rail to a 1 in. round, and the web to a 1 in. x 1 in. x $\frac{1}{8}$ in. angle. One piece alone was run through the mill, and the power required for each pass recorded. The second chart was taken during normal rolling on the above sizes. It illustrates the building up of peaks by overlapping passes with several pieces in the mill. The maximum swing shown is 1,000 kw, whereas the maximum taken by a single pass is 560 kw. The third chart indicates revolutions per minute, and illustrates the very small drop in speed of this set under load.

Figure 4 shows the same readings taken on the two-stand drive when rolling the flange to 2 in. x $1\frac{1}{2}$ in. x $\frac{1}{8}$ in. angles. The maximum peak under normal rolling is again 1,000 kw and the maximum individual pass 640 kw. Unfortunately, one of the heavier schedules was not being rolled at the time these graphic meters were connected in the circuit. During the hardest rolling, it is not unusual for the indicating wattmeter pointers to go off the scale at 1,600 kw, which is about 80 per cent overload.

In 2,700 hours operation on the two 14 in. mill drives, delays due to the electrical equipment have been 5 hours and 52 minutes, or .2 of one per cent. This delay time includes one or two occasions when the power was temporarily interrupted. Readings taken over a period of eight hours indicate that to roll 5 in. rails, the head being reduced to $1\frac{1}{2}$ in. x $1\frac{1}{2}$ in. x $\frac{1}{8}$ in. "T" section, the web to 1 in. x 1 in. x $\frac{1}{8}$ in.

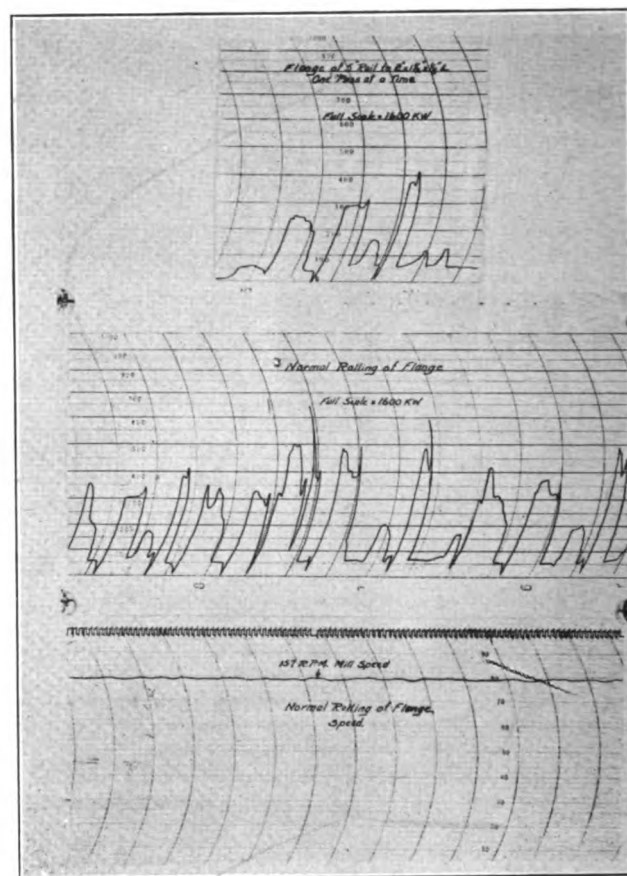


Fig. 4—Power required on two stand drive.

angle, and the flange to $1\frac{1}{2}$ in. x $1\frac{1}{2}$ in. x $\frac{1}{8}$ in. angle, requires 73 gross kilowatt hours, per finished ton, and to roll the same rail into $\frac{3}{4}$ in. rounds, 1 in. x 1 in. x $\frac{1}{8}$ in. angle and $1\frac{1}{4}$ in. x $1\frac{1}{4}$ in. x $\frac{1}{8}$ in. angle, requires 61 kilowatt hours per ton. It is of interest to note that the total power consumption since electrification has been 88.5 kilowatt hours per finished ton of product. This includes all the electric power used in the plant.

Maintenance and repairs on these drives during the year have amounted to \$65.19, of which amount \$60.00 was labor. This does not include the oil used in routine oiling of motors, but does include some used in switches.

The increase in tonnage with electric drive has been estimated at 10 per cent due to better maintenance of speed and greater ease of handling the drives. This is felt to be a very conservative figure. It has also been found that the roll breakage is less since electrifying. Since the heating furnace was changed over to powdered coal at about the same time, and more even heating is now being obtained, it is probable that this decrease in breakage is not entirely due to the drive, but the more even torques and higher finishing temperatures due to better speed maintenance undoubtedly have their effect.

The Effect of Oxidizing Gases at Low Pressure on Heated Iron

The Principal Agent in the Production of the Characteristic Facets of Oxide Is the Mixture of Gases Evolved by the Copper on Heating.

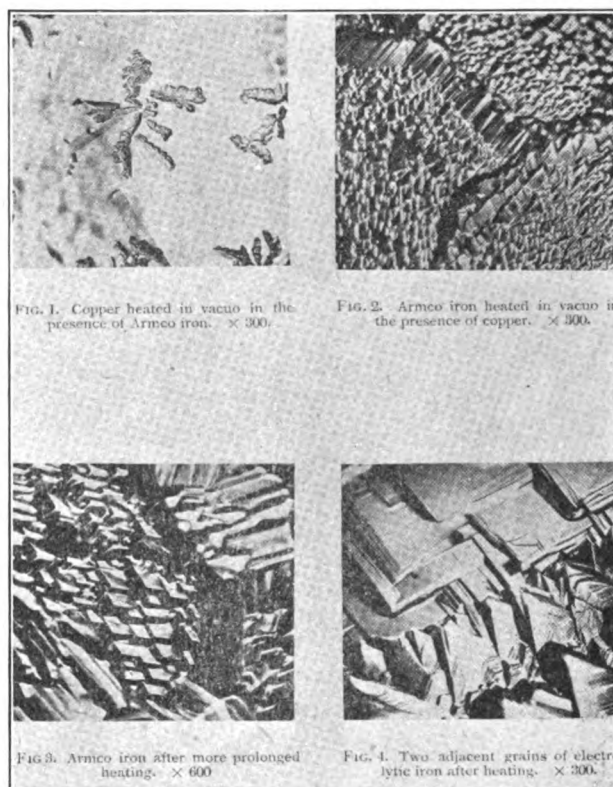
By H. C. H. CARPENTER and MISS C. F. ELAM*

THE experiments to be described in this paper originated in the following way: The authors were experimenting with the vacuum etching of copper which was heated in a silica tube, at temperatures in the neighborhood of 1,000 deg. C. The metal evolved a considerable volume of gas which, if allowed to remain in the tube, caused it to blister. If, however, the gas were pumped off as soon as it was evolved and the vacuum maintained, the copper remained bright and quite free from oxidation. Under these conditions the structure of the copper grains was rendered manifest by what may be termed a heat etch. It so happened that on one occasion Armco iron was placed in the tube with the copper, although not in contact with it. The tube was then evacuated and heated to about 1,000 deg. C. The gas evolved from the two metals was not pumped off, but allowed to accumulate in the tube. At the conclusion of the experiment, when the metals were withdrawn from the tube, it was found that each of them had altered considerably in appearance. On the one hand, the copper was found to have become coated with a layer of blue cuprous oxide, which in some places covered the metal completely, whereas in others it took the form of six-pointed stars deposited on the metal. On the other hand, the iron was distinctly lustrous, if rather dark, and appeared to be very deeply etched. Both specimens had been originally polished and sufficiently etched to show the outline of the crystal grains.

An experiment was then made by heating the iron itself in the absence of copper, and tests were made with Armco iron, electrolytic iron, and Swedish iron. In each case a considerable volume of gas was evolved, but no etching effects were produced and the iron appeared to be slightly oxidized. The characteristic etching effect observed in the previous experiment therefore was evidently due to something evolved from the copper.

A series of experiments was then instituted to study the progress and characteristic features of the etch produced on the iron when heated with copper. In all these cases the metals were separated from one another in the tube. The structure of the iron as revealed under the microscope was found to depend both on the period of heating and the temperature. After short periods, such, for instance, as half an hour, at 1,000 deg. C., the surface was found to be covered with small, somewhat irregular facets, whose orientation was constant on any one crystal but differed as a rule on passing from one crystal to another. Fig. 1, Plate I.

shows the structure at 300 diameters of the surface of the copper. This is hardly etched at all, although evidences of twin crystals are manifest. In the center is a blue star of cuprous oxide of very characteristic appearance, and deposits of this constituent are also visible in other parts of the field shown. Fig. 2 shows at 300 diameters the appearance of the surface of the iron after the above treatment. Portions of three grains are visible. On each of them will be observed



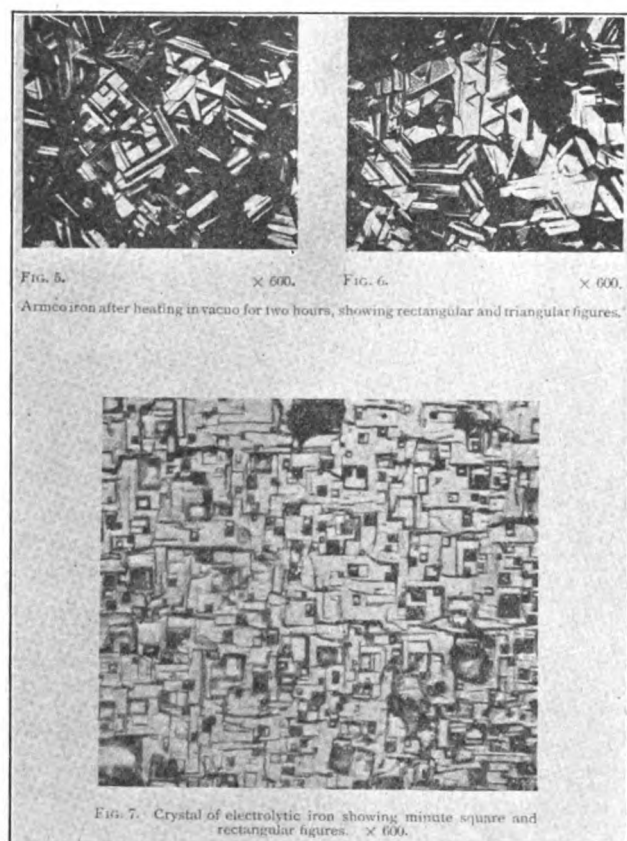
characteristic facets which are constant in direction on any given crystal, but vary from one crystal to another. There are also decided differences of level between the tops of the facets of the adjacent crystals. Steeply sloping surfaces connect one grain with another, and these slope to different extents. Between one crystal and another the etching is so deep as to produce what may be called a valley.

The differences of level on passing from one grain to another became still more marked as the heating was carried further. The individual facets then became larger and more regular, but the surface was rendered more uneven. Fig. 3 shows at 600 diameters the struc-

*Paper presented before British Iron and Steel Institute Annual Meeting, May, 1922.

ture of Armco iron after the more prolonged etching. Regular brick-like facets are visible in the center of the field. The dark area bounding these on the right is a sloping boundary, while the facets beyond are out of focus owing to the difference of level. Fig. 4 represents at 300 diameters the structure of two adjacent grains of electrolytic iron which are much larger than those of Armco iron, and are both approximately in focus. The facets in the upper half of the field strongly suggest an orientation parallel to the cube face, whereas those in the lower half represent a section of a crystal cut obliquely. Not only were the crystals of electrolytic iron larger than those of the Armco iron, but also the facets themselves.

On heating for a longer period, say for two hours, the surface became still more uneven and was found to be covered with perfectly regular squares, rectangles,



and triangles, together with other figures of less regular shape. Figs. 5 and 6 at 600 diameters are typical examples of the structures thus obtained. In the former the rectangle etch figures predominate and in the latter the triangle. In these cases, owing to the very deep etch, only certain parts of the field can be obtained in focus at any given time. It was observed that the size and general form of the figures varied somewhat in different experiments owing, doubtless, to slight differences in pressure, and to variations in the composition of the gases evolved from both metals. Occasionally very minute etched figures were obtained, such as are illustrated on Plate II, Fig. 7, at a magnification of 600 diameters, which represents part of one crystal in which the etched figures appear as minute squares and rectangles. Substantially the whole of this field is in focus. The three or four irregularly shaped figures observed are due to slight porosities in the iron.

It remains now to consider what the etched figures really represent. The authors' first idea was that the structures observed were those of the etched iron, more particularly as the form of the figures agreed very well with what is known as to the crystal forms of gamma and alpha iron. It very soon became evident, however, that the hypothesis was not correct in this form. It was found that, under certain conditions, small black shining crystals were formed on the surface of the iron, in addition to the etched figures described above. It was thought that these might be an oxide, and in removing some with a penknife in order to test it with a magnet, it was noticed that the "etch" layer could also be removed, revealing unaltered iron underneath. It appeared therefore that the characteristic etch figures were due to an oxidation of the iron during heating, and that accordingly they must be ascribed to an oxide and not to the metal. General support to this view was given by the fact that the copper itself was, as has been mentioned, also oxidized, the surface in certain places being almost completely covered with the characteristic blue cuprous oxide.

Further experiments were then carried out to determine what relation the structure of the oxide bore to that of the iron. It was noticed that if the specimen were heated to 1,000 deg. C. several times, there was no change in the shape or size of the characteristic etch figures, although it is obvious that on every occasion a change in the crystal form of the iron itself must have taken place on passing through the Ac_3 inversion and back again through Ar_3 . In other words, it is clear that the alpha to gamma and gamma to alpha change had no influence on the facets once they had been produced. Moreover, on marking a particular area before heating it could be shown that its structure corresponded with that of the original alpha iron crystal. The boundaries were the same in both cases. On repolishing and etching after heating it bore, however, no relation to the metal underneath, which had recrystallized in passing through Ac_3 and Ar_3 . Furthermore, upon heating the specimen of the iron below 900 deg. C. it developed the same characteristic etch facets as at 1,000 deg. C., although the time required was considerably longer (a minimum of two hours). It is clear therefore that the formation of the oxide begins below 900 deg. C. and that it takes its shape from the structure of alpha iron, and having once begun it continues to grow, regardless of the phase changes which take place in the iron underneath on passing from alpha to gamma and back again. The authors do not regard the process merely as an oxidation of the iron crystals, by means of which the structure of the iron is made manifest, so much as a growth of crystals of an oxide, the orientation of which is determined by the iron on which they are first formed. In certain instances the valleys produced at the boundaries are caused by the growth of oxide crystals away from the true boundary in two directions, the slopes of the valley being made up of the "sides" of the crystals. It will be noticed that these are striated in a regular manner corresponding with the orientation of the facets observed on the surface.

The fact that one substance will assume the same orientation as that of another on which it is crystallizing, provided they are isomorphous, is well known. This was established, for example, by Mr. C. V. Baker¹

¹"Journal of the Chemical Society," 1906, vol. lxxxix, p. 1120.

in his experiments on "the formation of regular growths of crystals of one substance upon those of another." Parallel growths of sodium nitrate crystals on calcite surfaces are shown on Plate XX, Figs. 63, 64 and 65, of Sir George Beilby's book entitled "Aggregation and Flow of Solids." It seems probable, therefore, that in the present case the oxide first formed is magnetite Fe_3O_4 , which has a cubic symmetry like alpha iron. The surface crystals, however, which were removed with a penknife, were not attracted by a magnet, indicating that they had been further oxidized, probably to Fe_2O_3 , without change of form. It is well known that hematite crystallizes in the hexagonal system, but this oxide has been obtained in a form pseudomorphous with magnetite by heating the latter in a blow-pipe flame for several hours. The crystals oxidized without change of form.² A type of structure somewhat similar to that described above was obtained by Osmond and Cartaud.³ They heated to redness a crystal of iron (which had one of the cube faces polished) in a nickel crucible packed with calcined magnesia and covered with cast iron shavings. To use their own words in describing the results of this experiment: "The polished face oxidized naturally and displayed square figures strongly resembling corrosion figures. * * It seems that the oxidation has been regulated by the structure of the metal."

As has been already stated, the characteristic structures of oxide described in the present paper are only produced under the combined influence of the gases evolved from both copper and iron. The mere oxidation of the iron which always takes place to some extent when it is heated by itself in an evacuated silica tube, does not produce these structures at all. What has to be explained, if possible, is the oxidation of the iron in a particular way under the combined influence of the gases simultaneously evolved both from iron and copper. The effects are only produced by copper containing the gases normally present in the metal. If the copper be previously heated in vacuo several times until no gases are evolved and be then heated with iron in an evacuated tube, it remains quite bright, while the iron oxidizes slightly without the production of the characteristic facets of oxide. Both the composition and volume of the gases contained in copper vary within fairly wide limits. Several samples of the metal, however, produced similar effects on the iron. The action therefore clearly takes place with gases whose composition varies to some extent. The gases collected when one specimen of the copper used in the authors' experiments was melted in vacuo, gave the following results on analysis:

Hydrogen sulphide	61.2
Carbon dioxide	34.9
Oxygen	1.1
Residual gas (nitrogen)	2.8

It is to be noted that this mixture contains only just over 1 per cent of free oxygen, but that there is a considerable amount of oxygen present combined with carbon and sulphur. Less information exists with regard to the gases present in iron. The majority of gas analyses have been carried out on steels, and in these cases the gases appear to consist of mixtures of the oxides of carbon together with hydrogen and nitro-

gen. It is impossible to predict what would be the equilibrium in a system composed of the metals, copper and iron, at temperatures of from 900 deg. to 1,000 deg. C., which was evolving a mixture of the above types. Broadly speaking, however, it appears that under these conditions the atmosphere produced is decidedly oxidizing both as regards the copper and the iron. In their experiments the authors have noticed the deposition of free sulphur in the cooler parts of the quartz tube. This points to the decomposition of the sulphur dioxide always present in the copper, and the result would be the production of free oxygen. Another source of this gas is possibly the decomposition of some cuprous oxide. The fact that the production of the characteristic facets of oxide requires a period of considerable duration for its completion is due, no doubt, to the gradual liberation of the gases over this period. Those contained in and evolved from the copper must be held to be the chief cause of the characteristic structures of iron oxide produced, but the influence of their possible interaction with the gases evolved on heating the iron itself must not be lost sight of.

Summary.

Samples of Armco, electrolytic, and Swedish iron were heated from below 900 deg. to above 1,000 deg. C. in an evacuated quartz tube and oxidized slightly without producing any characteristic crystallographic features on the surface of the metal. If, however, a specimen of copper be introduced as well containing the gases which are ordinarily present in the metal, a reaction sets in resulting in the gradual production and development of characteristic facets on the surface of the iron. These are due to the production of what is probably the oxide Fe_3O_4 , which subsequently passes to Fe_2O_3 without change of form. The oxide of iron originally produced is isomorphous with alpha iron, and the orientation of the oxide produced on any given crystal of iron is determined by the orientation of the alpha iron itself. It is, in other words, "a parallel growth" of the magnetic iron oxide. Once produced the form of the oxide is uninfluenced by heating the specimen to a temperature at which gamma iron is formed. A somewhat similar phenomenon was observed sixteen years ago by Osmond and Cartaud. The principal agent in the production of the characteristic facets of oxide is the mixture of gases evolved by the copper on heating.

STUDY OF FLUORSPAR INDUSTRY

R. B. Ladoo, mineral technologist of the Bureau of Mines, spent the entire month of April in the examination of the fluorspar deposits of the western states. On this trip fluorspar mines and mills were examined in New Mexico, Nevada and Colorado. Information obtainable on fluorspar deposits in Arizona, California and Utah indicated that deposits were not sufficiently important to warrant examination. None of the mines or mills visited was in operation, and it was evident that many of the deposits opened, particularly those of New Mexico, were war developments which can not be considered of great importance under normal conditions. The information obtained on this trip will be used as the basis of a report on the mining of fluorspar in the western states.

²Friedel, "Bull. Soc. Franc. Min.," 1894, vol. xvii, p. 450.

³"Journal of the Iron and Steel Institute," 1906, No. III, p. 481.

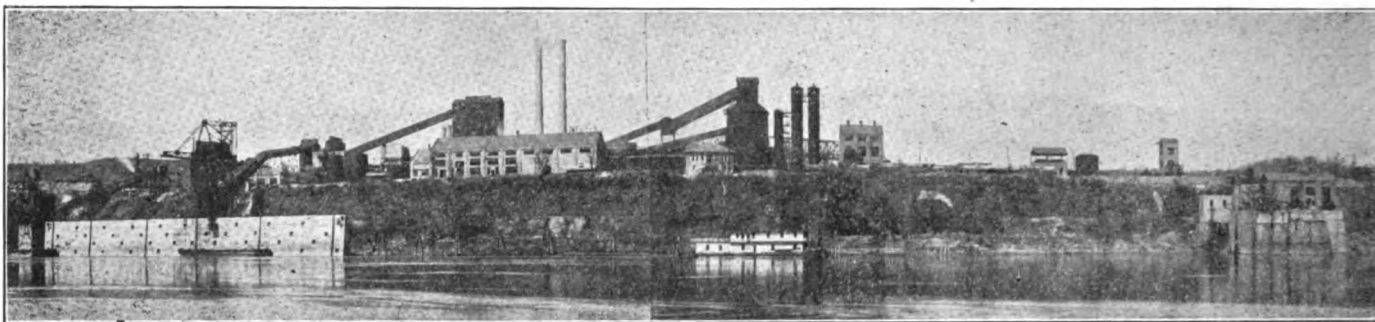


Fig. 1—General view of by-product coke plant.

By-Product Coke Plant at Midland

The Pittsburgh Crucible Steel Company Has Completed a Modern Plant Consisting of 100 Koppers Ovens at Midland, Pa.

THE By-Product Coke Plant of the Pittsburgh Crucible Steel Co., consisting of 100 Koppers ovens is situated at Midland, Pa., about 34 miles below Pittsburgh on the Ohio River on the site of an old Bee Hive plant. The original plans called for a plant built with government assistance as a war time measure to supply toluol and ammonium sulphate; but after the Armistice these arrangements were concluded, and the plant completed by the Pittsburgh Crucible Steel Co., a subsidiary of the Crucible Steel Co. of America. The location makes possible the use of the cheap water transportation giving the plant a decided advantage over those dependent on rail haulage.

As a source of raw material for the By-Product Coke Plant, the Crucible Steel Company operates a coal mine at Crucible, Pa., 69 miles above Pittsburgh on the Monongahela River at Glassmere, Pa., on the Monongahela. The mine at Crucible is in the Pittsburgh seam, admirably located and is capable of large development. As the acreage here is large and the coal readily mined and delivered into barges on the river, this is logically the source of supply of most of the coal for the By-Product plant. The mine at Glassmere is in the double Freeport seam and has a smaller acreage. At present it is not possible to load barges from the mine but when the river work under way is completed it will be possible to deliver coal from this mine into barges for shipment to the By-Product Coke Plant.

Coal is taken from the barges by a Mead-Morrison hoist having a six-ton bucket with a capacity of 600 tons per hour when working in free coal. The lift at normal pool stage is 75 feet and the speed of hoisting is sufficient to make two trips per minute.

The hoist is provided with a two hundred ton bin from which the coal is fed by a shaking feeder on to a 42 in. conveyor belt. This conveyor is 605 feet long and the idlers are equipped with roller bearings to decrease the strain on the belt. The storage bin here serves to balance the capacity of the belt, which is 300-326 tons per hour, and the hoist; and to keep the belt supplied with coal while charging barges. This first conveyor handles not only the coal for the coke

plant but also the steam coal and coal for the gas producers. The coal is delivered into the junction tower at the rate of 300-325 tons per hour where it is divided—250 tons per hour going on a 36-inch belt to the breaker and mixer building and the remainder on a 42-inch belt to the loading station, where if desired it may be crushed by a 54 x 54 roll crusher and screened into lump and slack for the steel mill. The capacity of this crusher is sufficient to take the entire amount delivered by the river conveyor.

As the river is not navigable part of the year suf-

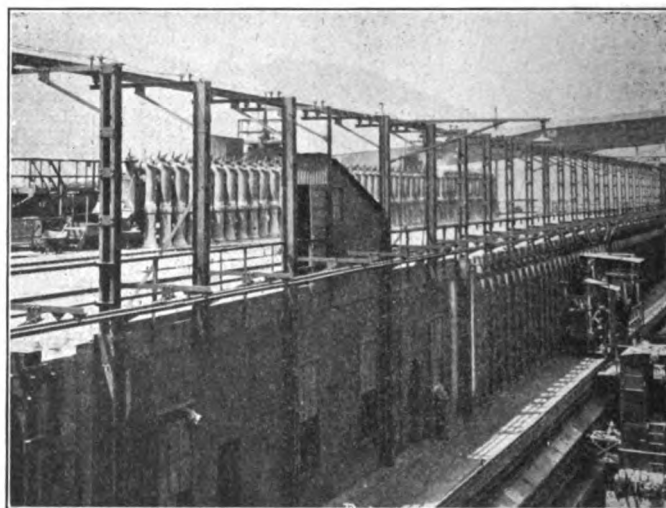


Fig. 2—View showing top and discharge side of ovens. Quenching car locomotive at extreme right.

ficient storage must be provided to allow the plant to operate during this period. This is taken care of by extending the ore yard and car dumper. Coal loaded into cars at the loading station is dumped at any desired point in the ore trough by the movable Wellman-Seaver-Morgan Car Dumper, which also handles the ore. From here it is stocked by the ore bridge. The maximum capacity of the storage yard is approximately 200,000 tons of coal giving 90 days operation for the Coke Plant and Steel Mill.

In reclaiming coal it is loaded on cars by the ore bridge and transferred to the track hopper. This receives coal in two sets of hoppers and delivers through shaking feeders on to a 36 in. belt which in turn delivers it into the same junction house which is the terminal of the river conveyors. If desired it is possible to take run of mine coal from stock in cars, crush and screen it into lump and slack and return it to cars.

The coal handling is thus flexible; and large storage capacity and handling facilities obtained with small additional expense by utilizing the surplus capacity of the Blast Furnace Equipment.

The coal from the junction tower is delivered to the top of the breaker and mixer building through the Bradford Breaker to four 200-ton mixer bins. From these it is delivered to the mixer conveyors and the hammer mill and then to the 1,800 ton storage bin on top of the ovens. This bin is divided by a central partition so that it is possible to charge two kinds of coal in the ovens. From the barges in the river to the point of delivery at the top of the bin on the ovens the difference in elevation is 207 feet.

The ovens are Koppers 500 cubic foot ovens, 15 $\frac{3}{4}$ in. wide at the pusher side and 18 $\frac{1}{4}$ in. at the coke side. The jamb brick are unusually thick giving very effective insulation of the first flue and are also so arranged that the luting clay is not next to the buckstays. In case of gas leaks through the luting clay the flames will not have a chance to come in contact with the buckstays and cause them to bend. Once this process has started it is very difficult to stop and a leaky battery is the usual result.

The general arrangement of the ovens and machinery represent Koppers standard practice. The details of the present pusher track however, presents a difference from the usual practice in that there is no

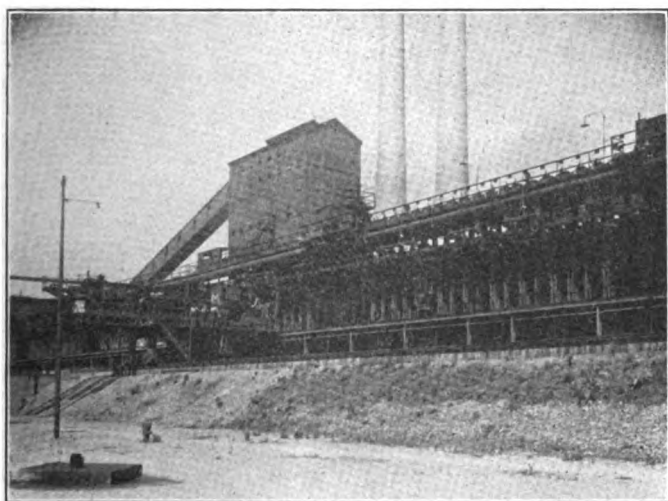


Fig. 3—Pusher side of ovens, showing pusher, central coal storage bin over ovens and gas collecting mains.

provision for taking the thrust of the ram on rear set of wheels. The wheels next to the oven are double flanged while those on the outside are single flanged with the flange on the outside, allowing this wheel to slip but preventing it from taking any thrust. The electric circuit for the pusher machine has a separate circuit breaker in the sub-station so that any attempt to push a stick by holding in the circuit breaker in the pusher cab will cause the breaker in the sub-station

to act. There is also a graphic meter in this circuit so that it is possible to observe whether there are any ovens which cause trouble in pushing. This arrangement has proven quite successful although viewed with suspicion at first. With the twelve foot embankment close to the rear wheel of the pusher this is apparently a very satisfactory solution.

The coke from the ovens is pushed into a quenching car propelled by an electric locomotive, quenched and dumped from the quenching car onto the coke wharf. From here a 36 in. belt conveyor takes it to a rotary

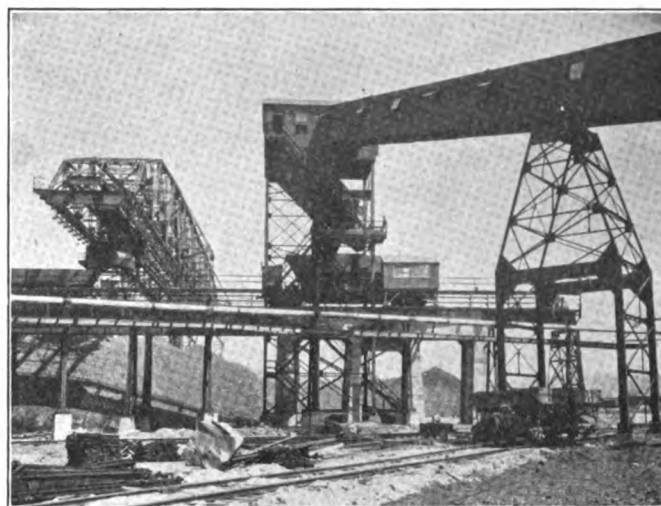


Fig. 4—Coke loading station, showing electric transfer car for conveying coke to blast furnace. Coal storage bridge at rear.

screen having 1 $\frac{1}{4}$ in. round holes. The furnace coke can either be loaded on cars on the coal handling level or sent to the storage bin above the transfer car which runs over the trestle to the blast furnace bins. The coke which goes through the 1 $\frac{1}{4}$ in. round holes drops onto an 18 in. belt which conveys it to a shaking screen having $\frac{7}{8}$ in. round holes. The material falling through the holes is sent to the boiler house for fuel while the larger coke is sold as domestic fuel. Below this screen are two tile lined bins holding about a car-load each. The tile lining seems to be standing the wear exceptionally well.

The By-Product Building houses all the by-product apparatus, the ammonia still not being in a separate building as in some of the recent plants. The exhausters are of the positive type—175 cubic feet per revolution. These are sufficient to take all the gas from both batteries, and the tar extractor, reheater and saturator are designed so that either may be operated with either exhauster but one is sufficient to take all the gas. The saturators are of the elliptical type with two ejectors and drain tables and three sulphate driers. It is thus possible to remove and repair an ejector while the saturator is in operation and to have one sulphate drier down for repairs without changing saturators as two driers will handle all the sulphate a saturator will produce.

As originally installed the wall between the booster room and main by-product apparatus room was only carried part way up to allow the hand crane to serve the booster room as well as the apparatus room, but it was believed that this advantage was outweighed by the danger of gas leaking from the apparatus room

being ignited by the motor driven boosters, so the wall was made solid. The boosters are positive machines driven by 275 horsepower slip ring alternating current motors through a Lenix Drive. The speed of the motors is controlled by a master switch operated directly by the movement of the gas holder. The control will cause the booster to put all the surplus gas into the mill gas line. In case the Open Hearth Department where all the gas is used, does not require

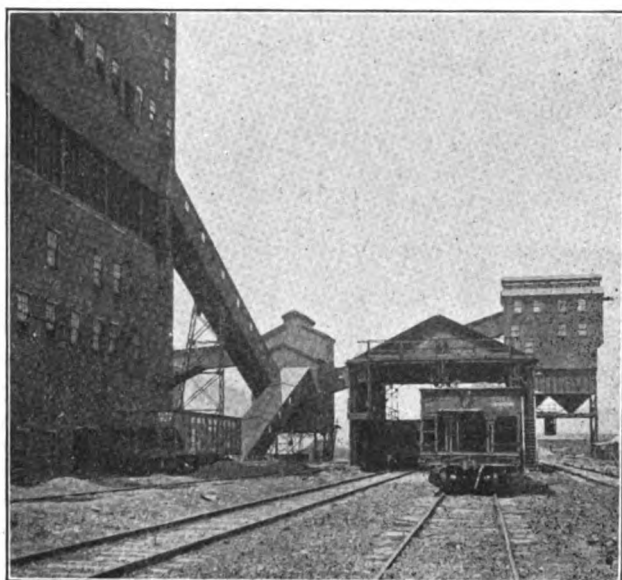


Fig. 5—Left to right: Coal crushing and mixing building; junction tower; coal to coke plant or steel work; rail coal to coke plant; right-rear, river coal to railroad cars for plant use.

the full amount, the excess will be released into the bleeder line through a multi-port relief valve set at 5 pounds pressure. If desired however, a manual control in the booster room may be used.

The tar and liquor pumps are motor driven, direct connected centrifugal pumps with steam driven duplex pumps as spares. Centrifugal lime pumps, motor driven are also used for providing lime feed to the ammonia still. Tar is delivered through a four inch line direct to the open hearth storage tanks without the necessity of loading it into tank cars. Coking 1,800 tons of coal a day and taking the open hearth requirements as 6,000,000 Btu per ton of steel there will be available from the coke plant sufficient gas and tar to produce 1,390 tons of steel per day in the open hearth.

As the present coal handling tracks of the plant runs over a fill on the site of beehive ovens which were in a fair state of repair at the time by the by-product coke plant was built, the difference in the open hearth department fuel bill, had the old beehive ovens been used to produce the coke for the blast furnaces, and natural gas been purchased as in previous years, can be readily computed.

The benzol department is fortunate in having the final gas cooler and benzol scrubbers located close enough to the building so that one man can operate the entire set of apparatus for recovering the light oil. This is a great advantage as the responsibility is not divided between the by-product and benzol departments as in many plants. The main benzol building houses the light oil stills and finishing stills, the agi-

tator being in a separate building at the other end of the benzol enclosure.

The finishing stills are only designed to turn out 50 per cent of the finished product as pure benzol or toluol, it being expected that the bulk of the demand would be for motor benzol or other products not requiring as close fractioning as pure benzol or toluol. Duplex steam pumps located in the main building handle the different products. The absorbent oil is pumped by rotary pumps each driven by a separate engine.

The storage tanks are not located in a building as in many of the recent plants but are outdoors. Those intended for products liable to freeze are insulated and have heating coils.

To prevent loss of oil all the drains do not go direct to the sewer but to an intercepting sump where any oil may be recovered and pumped back into the system. Used absorbent oil and residual from the finishing still are pumped to the tar tanks.

All the electric wiring in the plant is carried in underground conduits. The main lines from the power house to the sub-station, both direct and alternating current are in duplicate. Should an accident disable both of these lines power can be obtained by a tie from the river pumping station. The main high tension switches have sufficient rupturing capacity to take care of the full generating capacity of the power house. Since the actual load on the direct current machinery is small it was deemed inexpedient to install rotary converters at the sub-station but to use the converters

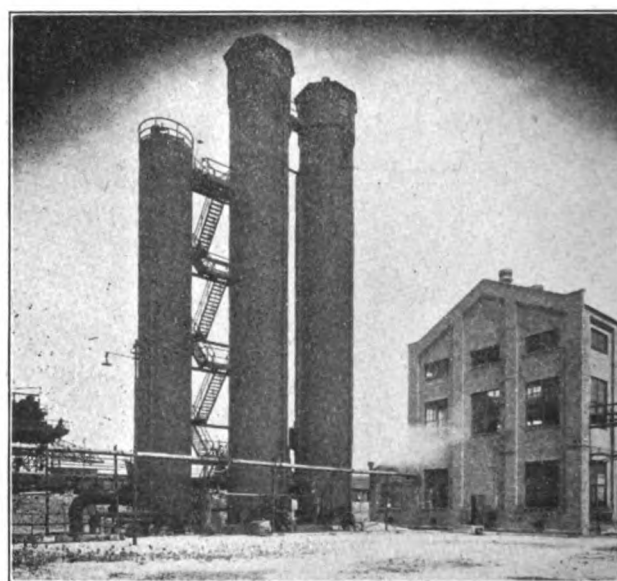


Fig. 6—Benzol scrubber, final cooler and benzol plant. Two benzol washers and one final cooler shown were manufactured by Treadwell Construction Company.

already in operation in the power house. With the complete duplication of units and switching apparatus in the power house the interruptions of coke plant operations due to the power being off have been very few.

Steam is supplied from the blast furnace boiler house and the coke plant is also dependent on the steel mill for its supply of water.

Wire Manufacturing in England and France

General Comparison of the Wire Drawing Practice of England and France With That of the United States—Reasons for Differences in Method of Manufacture Given.

By KENNETH B. LEWIS

THE wire manufacturer of England or of France has one strongly marked trait in common with his brother in America. He does not invite the public to share his troubles and achievements, nor to discuss his problems. There is little or none of the interchange of experience through the technical press or the engineering societies that marks many other branches of the steel industry. The more one knows about wire, the less he talks, and though this statement may seem to classify the present writer rather unkindly, it is none the less true. Our wire manufacturers travel abroad, and the foreigners visit us, particularly the British, and while the differences in practice are noticed and criticized, no one is convinced. Few changes of practice are attempted as a result of these visits, and those few are frequently disastrous.

In recent visits to Europe, I have had an unusually good opportunity to compare in a very general way the wire drawing practice of England and France with that of the United States, and to go far enough into the difference to assign to each a logical reason. I look upon the foreigner no longer as an amiable eccentric, but as a man who has cleverly adapted his wire drawing practice to conditions outside of the industry, and beyond his control. In England particularly, conditions of land tenure, character of labor, and the influence of trade unionism, combine in various ways to affect profoundly the practice in the wire mill. These influences affect the problem in so many degrees and from so many angles that one scarcely knows where to begin a discussion of them.

It is commonly reported that the British make better wire than we. They do. The statement should, however, be amplified. They make better wire than we *do make*, but not better than we *can make*. The wire industry falls naturally into three divisions: the rolling of wire rods, the drawing of wire and the working up of the wire into finished articles. With us these three divisions, or at least two of them, are very commonly found under a single management, and a single roof. It is frequently found that the finished product of one division, which is the raw material of the next, can be considerably cheapened if the next division can take a product less accurately sized. The next division finds it possible, at a slight sacrifice in efficiency, to absorb the cheaper product, and to pass on a satisfactory raw material to the next in line. The gain greatly outweighs the loss, and as it all goes into the same pocket, a net gain is registered for the combined industries, while one or more of the divisions is forced for the common good to lower its standard.

In England the wire maker knows little and cares less about the problems of the rod roller. He wants

Mr. Lewis is manager of the wire machinery department, Morgan Construction Company, Worcester, Mass.

round rods true to gauge and gets them. The nail maker, who draws no wire, wants his wire round and true to gauge, not because the carpenter cannot drive a scratched nail, but because the output and upkeep of the nail machines are better with first-class wire. Furthermore, the wire drawer and the nail maker are 100 per cent unionized. They are on a piecework basis, and if they do not like the raw material they get they will walk out. They consider they have no interest in common with the boss. Savings mean nothing to them. Earnings are everything.

The various divisions of the wire industry are very reluctant to merge to a completely integrated unit. The British companies are old and firmly established. They are family affairs, and the Britisher is not easily transplanted. He wants his family business with its small but steady profit, and his son wants it after him. He does not shift readily from place to place or from business to business. Moreover, a consolidation which involves expansion is a big undertaking in England on account of the difficulty of buying land. The Englishman regards his land as he does his business, not as a thing to speculate with, but to keep and get dividends from. There is no land held for speculative purposes. It is all producing. You may lease it, but, generally speaking, you cannot buy it, and there is not much fun sinking money in a big undertaking on leased land. The established units of the business are chiefly in congested districts, since they were laid down before the days of easy transportation. If they are to be brought together it must be in a new place. Will the workmen follow the plant? That's an open question. The British working man does not care for change any more than the manufacturer. One of his ambitions is to die in the house where he was born. The British manufacturer cannot count on attracting to a new location a sufficient number of floaters. There are no immigrants in England—no great floating body of unattached young men with nothing but muscle, ready to be shaped into skilled or semi-skilled laborers. The manufacturer can look only to the ranks of union labor. He cannot make wire drawers or nail makers. The union makes them, the boss takes them.

The labor union is the outstanding factor in the industry from every angle. British wire is generally drawn very accurately to gauge, whatever its grade. In conditions under which the American wire drawer handles four, five and even six blocks, the British wire drawer is permitted by the union to run only two. He has an abundance of time on his hands. His pay, while low in dollars per day, is high in dollars per unit of production. The boss can get square with him only by insisting on a high degree of accuracy in the finished product. The boss studies out other ways to keep the wire drawer busy. A Yankee would say that he was "saving at the

spigot and wasting at the bung hole," but the critic must remember that the bung hole is in charge of the union, and is kept wide open, and that every drop saved at the spigot is net gain to the boss. The wire drawer is required to fix his own dies. This saves money, but it helps to rivet the shackles of trade unionism onto the boss. It helps to make and keep wire drawing a highly skilled trade. The wire drawer is required to point his wire frequently with no other tools than a hammer and anvil. The arrangements for drawing the point through the die are of the crudest description and great wasters of time, but the wire drawer has time to waste. In some mills the wire drawer must walk into the baker, pick up a bundle of rod from the floor and carry it in his arms to the bench. When I was tempted to marvel at the shortsightedness of the superintendent in permitting such inefficient practice I recalled that the man's time and labor were already paid for and that this service cost the mill absolutely nothing. The same considerations result in the use of small rod bundles. All the expenses connected with the production and handling of large bundles would fall on the proprietor. All the profits would go to the union wire drawer.

The British wire drawer is a highly skilled artisan. He serves a long apprenticeship, and works his whole life at the bench. He knows instinctively how to vary his drafting and the shape of the die hole to suit the variations in the stock, and he does certainly make beautiful wire. So did the American wire drawer in the good old days before the changing character of our labor supply made it necessary to take the brains out of the operator and put them into the machinery.

The British cleaning house is not quite the choking, steam-filled purgatory to which we are accustomed. I do not recommend it precisely as a health resort, but you can at least walk about without necessarily ruining a hat and coat, and on leaving you can blow your nose without burning holes in your handkerchief. The first thing I noticed was that all the tubs were of stone, reported to be everlasting. We have all heard of these stone acid vats from returning travelers. Some of us have tried them here in America, but they invariably cracked as soon as the solution got up to pickling heat. In England the solution gets no more than lukewarm, and the reason the wire cleans is that the acid is muriatic. This is not reckless extravagance on the part of the British wire manufacturer. Muriatic is his cheapest acid. In America we not only have large sulphuric deposits, but we recover thousands of tons of sulphuric acid as a by-product in the smelting of sulphide ores of the non-ferrous metals. In England sulphuric is the high priced acid, and muriatic is the cheap by-product. At this gentle heat generated by the chemical action of acid on steel, the stone tubs last forever, and on account of the strength of the acid, pickling is not prohibitively slow. The acid cannot be heated. Sulphuric acid is a liquid. Muriatic acid is a gas, which for commercial use is dissolved in water. At such temperatures as we induce in our vats by the use of steam, the muriatic acid would be driven out of solution and lost.

British practice seems to favor a long baking at comparatively low temperature. Whether this fully explains it, I do not know, but certainly their wire is more carefully "gotten up," as they express it, and if required will stand more drafting before the coating is lost.

Soap is the favorite lubricant in the die box, or rather the plate stand, as cast iron dies are unknown; not powdered soap, however, but soap in cakes or small chips. The cakes are commonly clipped onto the wire in pairs

with a spring clip, and the rod is thoroughly soaped in the first draft. On succeeding drafts it is soaped again, either with cakes or with the broken chips and powder recovered from the first stand.

The British annealing practice does not seem to differ materially from ours.

In the matter of drawing benches, the differences are not particularly noticeable. The English bench is apt to be very low, perhaps 24 inches, but the block stands high above it so that the draft line is about the usual 30 inches from the floor level. The bench top is low enough to carry anvils, on which plates are battered.

Continuous machines for the dry drawing of coarse wire are much in evidence in England. They are of a variety of types, most of them familiar to Americans. Indeed, most of them have been tried here and condemned. Their work is no better in England than in America, but it seems better by contrast. The unions consent to classify a continuous machine as one block, and a man is therefore permitted to operate two machines. However small his output, it is bound to beat the performance of two single-holers. Three general types of machine are in service: the common slip machine, the machine with bronze segments which slip in a groove in the block face, and various arrangements of the differential gear principle. On account of their relatively large output, the British wire man nurses them along with greater care than we can afford to give them. The following figures indicate roughly the position of these machines in comparison with single holing in Great Britain, and in the United States:

Operation	British Output (10 hrs.)		American (10 hrs.)	
	1 Man 2 Blocks	1 Man 2 Con- tinuous Machines	Output	No. Blocks
2-hole No. 10	5040		9000	2
3-hole No. 11	4172	4480	8000	3
3-hole No. 12	3360	4028	7000	4
4-hole No. 13	2460	3920	6000	4
4-hole No. 14	2094		4700	5
5-hole No. 15	1346		3800	5

France.

I found the wire mills of France interesting, chiefly from the viewpoint of the antiquarian. This rather unkind statement might have been modified had I found time to visit some of the larger mills outside the devastated region, whose practice, I am told, more nearly resembles ours, but I report here only what I saw. The mills were picturesque outside as well as inside. I did not actually see one with a thatched roof, but momentarily expected to. Several of the plants had been stripped of machinery by the Visitors. In one case the buildings had been turned into a factory for the production of wooden furniture for German dugouts, and I had the pleasure of sampling the product while we talked. The manager was in Germany trying to locate and identify his machinery, and the master mechanic expressed to me privately his hope that the wire benches would never be found.

Two things that characterize French wire drawing as I saw it are small bundles and wet drawing. The rods are frequently coppered directly after pickling and drawn wet to all sizes. The coating did not seem as red as our "high copper" finish, and it was only after persistent and repeated questions that I accepted the statement that it carried absolutely no tin. It drew off rather quickly to a straw color exactly like our tin-copper coat, and it seemed to me that it required rather frequent renewal.

The coarse wire is not drawn out of tubs, but is allowed to lie on a standard reel after having been dipped in a gummy looking mixture called "sauce," whose composition I could not make out, the ingredients being outside my small vocabulary. The coarse wire in bundles of 40 or 50 pounds runs out quickly and apparently has no time to rust. Fine wire is drawn from tubs of rye meal liquor, as with us.

The wire blocks down to 12 inches diameter have wide faces and generally no extension pins, since the bundles are too small to climb high. The reel serving the ripping block is generally on the floor, but for the other blocks the reels are mounted on the bench behind the blocks. It is not difficult to strip these light bundles, and to lean over and drop them onto the reel, just as in our fine wire practice. Germany supplies much of this wire drawing equipment. It is said that the German practice is more like our own, but that they seem quite willing to let France continue her wet drawing. I judge that the practice alone is enough to keep France out of the export market. In a good sized wire rope plant I found the usual practice to be two drafts from the rod in lime and soap to the first patenting point, then wet drawing to finished size. Kink tests on the process wire did not inspire in me any great respect for wet drawing.

The wire benches are of the types advertised by the various German manufacturers, generally with reels on the bench as described, and frequently with very close set blocks worked alternately from both sides of the bench. The drawout tongs are permanently attached to each block in a recess below the flange. The benches seem very light for their rating, and I found it was common practice to draw the first draft or two from the rod on horizontal spindle bull blocks. On these ripping drafts a speed of 10 to 15 rpm. of a 22-inch block was considered quite daring, with finishing speeds running anywhere from 25 to 40 rpm., and occasionally with small blocks as much as 50. Drafting is, of course, much lighter than in dry drawing, more drafts being necessary for a given reduction in the ratio of about 9 to 7.

This wet drawing practice brings out the interesting fact that in the reduction of soft steel our annealing practice is based less on the requirements of the metal than on the life of the coating. I observed more than once that the British with their carefully prepared coating were regularly drawing to finer gauge from the rod than we consider commercially practical. The French mills practicing wet drawing, and renewing the copper coat at frequent intervals, have no difficulty in reaching 20 to 22 gauge for nails or netting wire without annealing, and one manufacturer reported that 24 gauge was his usual practice.

Sulphuric acid is the usual pickling medium in France. I was unable to get an accurate comparison of their acid consumption with ours. The difficulty of discussing technical matters in an unfamiliar language may be readily understood. The writer became expert at transposing from kilograms per metric ton into pounds per net ton, at full conversational speed, but had to draw the line at applying correction factors for 53-degree acid, which was the best France could get in war times.

Continuous machines seem to be more used in France than with us, though not so common as in Great Britain. I found two large installations of Horton machines for both wet and dry drawing in all sizes. The machines were chiefly five-holers. Knowing this type of machine to be an American development, the French are under

the impression that it is widely used here. The machines had water-cooled bronze seats and took nearly double the calculated power, the excess presumably going off in heat. They were kept in excellent condition and under careful manipulation showed production records that were really impressive. The following figures were reported to me by a prospective purchaser who had carefully checked the outputs in the plants of the "concessionaire." Though the information is not quite complete, it is accurate.

From	No. Drafts	To	Machines per Man	Output per Man
5	5	14	2	5700
..	5	15	2	4800
..	5	16	3	6000
..	5	16½	3	5500
..	5	17	3	4600
..	5	17½	3	4000
..	5	18	3	3300
15	3	18½	5	4400
15	4	19½	5	3100
15	5	21	5	2200
15	..	22½	5	1380
16	..	23½	5	1000
16½	..	25½	5	680
17	..	28½	5	500

NEW MERCHANT MILL PLANNED BY TENNESSEE COAL, IRON & R. R. CO.

Official announcement is made by George Gordon Crawford, president of the Tennessee Coal, Iron & Railroad Co., that a combination 10- and 12-in. merchant bar mill, two blocks long by 80 ft. wide and having a monthly capacity of 10,000 tons of plain or deformed bars, rounds and squares, is to be built at once at the works of the Tennessee company in Fairfield, a suburb of Birmingham. While the cost of the new mill has not been officially announced, it is stated unofficially that the figure will be approximately a million dollars.

The new merchant mill will be so located as to receive billets from the Fairfield blooming mill, to which tables will be added so that long billets can be delivered to the merchant mill without the necessity of switching cars. It will consist of a roughing train of six strands of 10-in. rolls, an intermediate mill of five strands of 12-in. rolls and a finishing train of two strands of finishing rolls, provided with 11-in. pinions, making it possible to use either 10-in. or 12-in. rolls.

A mechanical hotbed 255 ft. in length will receive the hot bars from the roll trains and, after cooling, the bars will be sheared and stocked in a stores and shipping room specially adapted for the storing of concrete reinforcing bars and with storage capacity for a limited tonnage of merchant bars. The bar mill and stocking building will be 80 ft. wide and 820 ft. long. The capacity of the mills is estimated at 10,000 tons of plain or deformed bars, rounds or squares per month. The mill is to be built to care for the increased demands for bars in the Southern territory and for export. Material for the construction of the mill will be ordered at once and construction will begin as soon as the materials are received.

The New Continuous Strip Mill of the Trumbull Steel Company

A General Description of the New 14-in. Hot Strip Mill Which Will Be Ready for Operation About June 1—Capacity of New Mill 140 to 600 Tons per Day.

THE plant of the Trumbull Steel Company will be augmented about June 1 by a new unit which is designed to roll intermediate sizes of bands, hoops and strips varying from $2\frac{1}{2} \times .045$ in. to $7 \times .060$ in. and thicker up to $\frac{1}{4}$ in. The finished product may be coiled or cut to lengths. This mill is an electrically driven, continuous mill with a continuous furnace heated by electric gas. The capacity of the new unit will vary from 140 to 160 tons per day, depending on the size of material rolled, and will fit in with the other mills of the strip department which consists of a 16-in. continuous mill, a 9-in. continuous mill, and a cold rolling department having 35 stands or rolls arranged single and in trains varying from two to four stands. The new mill was constructed by the Morgan Construction Company of Worcester, Mass., and is being erected by the steel company under the combined direction of Mr. Frederick Wille, consulting engineer of the Trumbull Steel Company, and the Morgan Construction Company.

Building.

This unit is housed in a steel building 1,200 ft. long and 100 ft. wide, consisting of 60 bays 20×100 ft. The roof is $1/5$ pitch double monitor type with continuous sliding wood sash on the lower part and continuous louvres on the upper part. The roof truss elevation is 33 ft. above the floor line. This building forms a continuation of the 16-in. mill building parallel to the 9-in. mill building and the pickling building and is easily accessible to the cold rolling department. The building is served by two 15-ton cranes mounted on 60-lb. A.S.C.E. rails. One crane is a three-motor single trolley double hook type with 50-hp. bridge motor, 10-hp. trolley motor and 50-hp. mainhoist motor; the bridge travel speed is 40 fpm., the trolley travel speed 175 fpm. and the hoist-lift 30 fpm. The other crane is a four-motor single hook type with 10-ton auxiliary hoist, the auxiliary hoist motor is 30 hp. and the other features are similar to the first crane. The six bays at the north end of the building will be used for a billet yard and will permit the storage of three 30×60 -ft. billet piles; 24 bays in the middle of the building will be devoted to the rolling mill with its furnace, motor-room, conveyors, etc., and the south half of the building will be used for the handling and storage of finished products.

Billet Yard.

The billet yard will be equipped with a 30-ton scale at the floor level, having 24-ft. platform and cradles for weighing billets and, also, with five cast iron billet skids which feed billets to charging conveyors. Dimensions: north end of building to first skid 143 ft. 5 in., from center line to center line of skids 6 ft. 8 in., center line charging conveyor to back of skids 17 ft. $8\frac{1}{4}$ in., floor line to top of skids (high end) $12\frac{3}{4}$ in.

Heating Furnace.

Morgan recuperative type of continuous heating furnace, using producer gas as fuel. This producer gas is developed in a producer gas plant situated west of the 9-in. mill; this plant serves both the 9-in. mill and the 14-in. mill furnaces. The producer gas plant is equipped with two Morgan and two Hughes gas producers. The heating furnace for the 14-in. mill has a Slick suspended roof, 11 cast iron water-cooled skids, magnesite brick on bottom of 4 ft. 6 in. inclined hearth and all of horizontal hearth. The air-exhaust is No. 9 monogram (Sturtevant) driven by $17\frac{1}{2}$ -hp. shunt wound motor. Dimensions: center line furnace to center line north end of building 210 ft., brickwork 34 ft. 2 in. wide by 37 ft. 2 in. long, center line of mill to discharge end of brickwork 6 ft. 2 in., center line of mill to charging end of brickwork 31 ft., width of hearth 32 ft., water-cooled skids 4 ft. wide by 7 ft. 7 in. long, spaced 2 ft. $7\frac{1}{2}$ in. center to center, length of brick hearth 27 ft. $9\frac{1}{2}$ in., 24 steel skids $2\frac{1}{2}$ in. by 9 in. by 15 ft. long spaced $13\frac{1}{2}$ in. center to center in brick hearth, slope of hearth 1:5, length of inclined hearth, measured horizontally, 22 ft. $5\frac{1}{2}$ in., length of horizontal hearth 5 ft. 4 in.

The furnace has the following equipment: An external charging conveyor with an over-all length of 36 ft. $3\frac{1}{2}$ in., supported by six cast iron stands having seven hollow cast iron rollers 15 in. in diameter by 18 in. long, which have a peripheral speed of 460 fpm.; from the face of furnace brickwork to center line of last roller 5 ft. $7\frac{1}{2}$ in. and from floor line to top of rollers 7 ft. $11\frac{1}{2}$ in. An internal charging conveyor consisting of five water-cooled rollers inside of the bearing furnace, with roll shafts inclined at an angle of 87 deg. with furnace and line of billet travel. The rollers of both the external and internal charging conveyors are driven by one 12-hp. dc. motor, the internal rollers being driven from the outside of the furnace by a line shaft and helical gears. Internal rollers are 8 in. in diameter by 14 in. long, the end $3\frac{1}{2}$ in. of rollers tapering down to 6 in. in diameter. The peripheral speed of rollers is 96 fpm. Morgan type of cross pusher having five steel pusher arms, operated by cranks on line shaft which is operated by a bell crank connected to the piston of a steam cylinder, with the entire cross pusher bolted to furnace buckstays. Dimensions: pusher arms $1\frac{3}{4}$ in. by $5\frac{1}{2}$ in. by 3 ft. 7 in., crank shaft 27 ft. $4\frac{1}{2}$ in. long by 6 $15/16$ in. diameter, steam cylinder 25 in. diameter by 2 ft. $7\frac{11}{16}$ in. long. Hawthorne type of push-out rolls; over hand pinch rolls $11\frac{3}{16}$ in. diameter by 10 in. long with a peripheral speed of 330 fpm., driven through gear reduction by 12-hp. dc. motor. Pull-out rolls with rolls, roll drive and top roll lifting mechanism bolted to the furnace steel work; the bottom roll, which is 10 in. in diameter by 2 ft. $5\frac{1}{2}$ in. long, is driven through spur

gear reduction by 5-hp. dc. motor; the top roll lifting mechanism is operated through a worm reduction by a 2-hp. dc. motor. The top roll is 10 in. diameter by 2 ft. 8 in. long. The bottom roll has a peripheral speed of 89 fpm.

Roughing Mill Roll Train.

The roughing mill roll train consists of four stands of horizontal rolls with an emergency shear, three vertical edging mills and a flying shear arranged as follows: emergency shear, 16-in. edging mill, two stands or rolls, 1-in. edging mill, two stands rolls, 12-in. edging mill and flying shear.

The roll stands are two high with open top housings, top roll adjusting screw $4\frac{1}{4}$ in. diameter by 3 ft. $3\frac{1}{2}$ in. long over all, four U. S. S. threads per inch; the bottom roll bearing is adjusted by wedges operated by screws on the side of the housings; the rolls are cast steel varying in diameter from 13.86 in. in the fourth stand to 12.54 in. in the first stand, length of body is 16 in., necks 10 in. in diameter by 13 in. long; wabblers are 9 in. in diameter by $5\frac{1}{2}$ in. long.

The emergency shear is the Edwards up-and-down type which cuts at a rate from 7 to 29 strokes per minute; the knives are 18 in. wide, the upper one traveling 5 in. and the lower one 3 in.; this shear and the 16-in. edging mill are driven through a gear drive by a 140-hp. General Electric motor.

other roll dimensions are the same as those of the roughing mill. From the center line of the fourth stand in the roughing train to the center line of the fifth stand in the intermediate train is 27 ft. 6 in.; from the center line of the fifth stand to the center line of the sixth stand is 9 ft. The two roll stands in the intermediate train are driven by a 1,250-hp. General Electric motor, which is connected directly to the sixth stand and to the fifth stand by a train of spur gears.

Finishing Mill Roll Train.

The roll housings of this train are the same as those of the roughing and intermediate roll mills. The rolls are cast iron clear chilled to 13 in. in diameter and vary in diameter from 14.4 in. to 13.6 in. The roll stands are spaced on their center lines as follows: from the sixth to the seventh 9 ft., from the seventh to the eighth 9 ft., from the eighth to the ninth 8 ft. 3 in., from the ninth to the tenth 7 ft. 6 in. The roll diameters in this train are so graduated that, when ground too small for one stand, a roll may be used in the next stand back. Each finishing mill stand is driven by an individual 800-hp. General Electric motor directly connected to the top pinion.

Equipment for Handling Finished Material.

Beyond the finishing roll train are guide troughs for guiding material to either the rotary shear or the vibrator; if the strip is to be shipped in lengths it goes to the

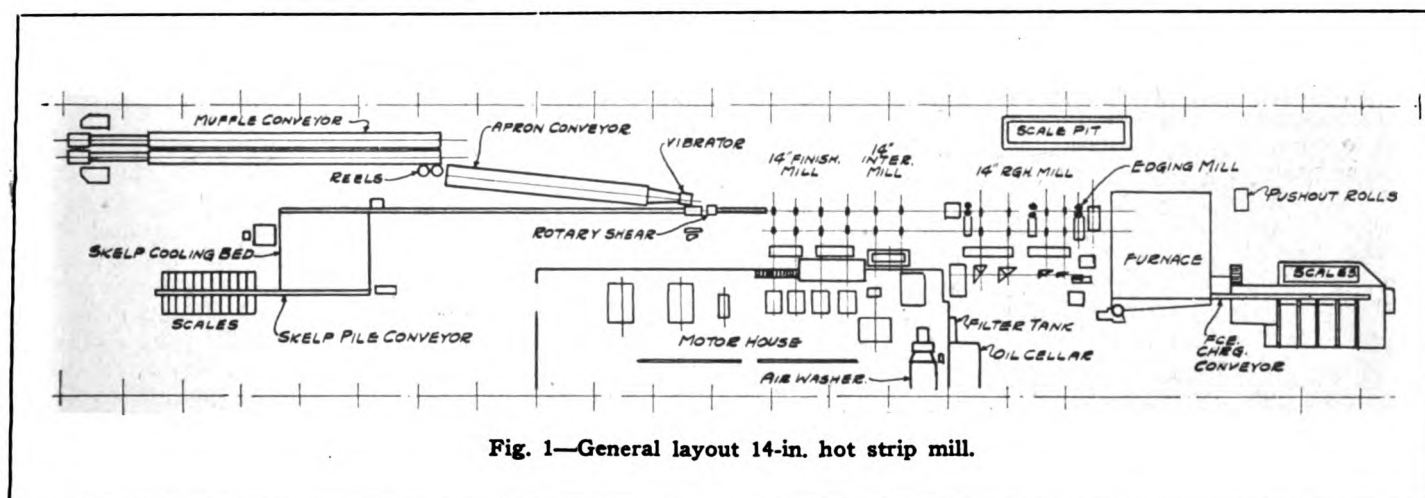


Fig. 1—General layout 14-in. hot strip mill.

The fling shear is an Edwards steam operated type; the width of the knives is 10 in. and the diameter of the steam cylinder is 12 in.

The following dimensions apply to the roughing mill train: center line of roughing mill train to center line of west building columns 36 ft. 6 in., face of furnace brickwork to center line of emergency shear 5 ft. 6 in., floor line to center line of emergency shears 2 ft. 7 in., face of furnace brickwork to 16-in. edging mill 8 ft. $10\frac{1}{2}$ in., center line of edging mill to center line first roll stand 4 ft. $7\frac{1}{2}$ in., center line first roll stand to center line second roll stand 6 ft., second rolling stand to 12-in. edging mill 4 ft. $5\frac{1}{4}$ in., 12-in. edging mill to third roll stand 8 ft. $9\frac{3}{4}$ in., third to fourth 9 in.

Intermediate Roll Train.

This train consists of two stands of rolls, the fifth and sixth with the same roll housings as the roughing mill. The rolls are cast iron chilled to 13 in. in diameter and vary in diameter from 13.6 in. to 13.2 in.; all the

rotary shear; if it is to be shipped in coils it goes to the vibrator. The guide trough to the rotary shear is straight and has an over-all length of 16 ft. $6\frac{1}{2}$ in.; two widths are provided, 6 in. and 9 in.; they consist of two 8-in. side channel, 10 cast iron bottom plates and five steel cover-plates. The guide trough to the vibrator first twists the material to the vertical and then turns on a 10-ft. radius to an angle of 14 deg. and 18 min. and delivers material to pinch rolls at the vibrator.

Beyond the finishing mill train is a rotary shear designed to cut strip into lengths varying from 12 ft. to 30 ft.; this shear, which is placed 22 ft. from the center line of the tenth roll, is equipped with two knives 8 in. wide on each rotating shaft and is driven by a 4-in. double belt. Between the final belt and the line shaft are two belts running on four conical pulleys. The line shaft, which is used in common by the rotary shear and the vibrator, is driven by a 5-in. double belt running on a pulley on the tenth roll stand lead spindle. From the rotary shear a Morgan skelp conveyor carries the cut

lengths to the cooling bed which consists of 43 cast iron rollers 10 in. in diameter and 8 in. long. The rollers are fastened to 1 3/16-in. diameter shafts by two set screws; the peripheral speed of the rollers vary from 170 to 510 fpm.; this conveyor is belt driven through one gear reduction by a 10-hp. General Electric motor. Dimensions: center line rotary shear to center line double pulley 4 ft. 5 in., double pulley to first roller 15 ft., center line to center line of rollers 2 ft. 6 in., floor line to top of first roll 2 ft. 8 1/2 in., floor line to top of last roll 5 ft. 2 in. The conveyor terminates in two piling rolls 10 in. in diameter by 8 in. long, with a peripheral speed varying from 246 to 738 fpm.; from the center line of the last table roller to the center line of piling rolls is 4 ft. 4 in.; the piling rolls are driven by a 5 1/2-hp. General Electric motor.

The cooling bed is a Morgan skelp type with reciprocating dogs. From the center line of the rotary shear to the cooling bed is 116 ft. 2 in.; the width of the cooling bed from the center line of the skelp conveyor to the center line of the pile conveyor is 28 ft. 5 in.; the length is 30 ft. 6 in. There are eight lines of dogs spaced 16 in. apart with a stroke of 18 1/2 in.; the stroke of the skelp conveyor kick-off is 22 1/8 in.; the dogs and kick-off are operated through clutches from the same gear reduction driven by a 20-hp. General Electric motor. Piles of cut lengths are tied before leaving the cooling bed.

The pile conveyor conveys the tied piles to twin scales; this conveyor consists of 13 cylindrical rollers 15 in. in diameter by 12 in. long, and 11 double conical rollers 13 in. long with 15-in. center diameter and 10 3/4-in. end diameters. The double conical rollers are arranged to dump on either side on the twin scales; their peripheral speed is 66 fpm.; they are belt driven from a drop pulley driven through worm reduction by a 10-hp. dc. motor. From the center line of the cooling bed to the center line of the scales is 31 ft. 9 in. The scales have a capacity of 30 tons; their platforms are 30 ft. long and there are 11 cast iron storage bins for each scale.

From the guide troughs material which is to be shipped in coils goes to the vibrator; this is a device for distributing strip in a serpentine form upon an apron conveyor. Strip is driven through the vibrator by two pinch rolls 14 in. in diameter by 5 1/2 in. long, having peripheral speed varying from 1130 to 2260 fpm. The vibrator itself may have from 110 to 220 vibrations per minute with variable lengths of vibrations; it is driven by an eccentric, which in turn is driven by a belt from the same line shaft as the rotary shear. From the center line of the tenth roll to the center line of the vibrator is 30 ft. 3 1/2 in.; from the center line of the mill to the center line of the vibrator is 3 ft. 10 in. The apron conveyor takes the strip in a serpentine form from the vibrator to the reels and acts as a cooling bed; it is driven through a reduction gear by a 10-hp. dc. motor. Dimensions: vibrator to foot shaft 10 ft. 3 in., foot shaft to head shaft 70 ft. 1 1/2 in., floor line to top of conveyor at foot shaft 2 ft. 4 3/4 in., at head shaft 2 ft. 1 in. At the head shaft of the apron conveyor are two reels for coiling the strip; these reels have collapsible cores raised and lowered by link crank rod and eccentric driven by individual 15-hp. dc. motor. The reels themselves are driven by individual 15-hp. dc. motors, with speed varying from 72 to 288 rpm. and are equipped with a pull-over device for transferring coils to the muffle conveyor; this pull-over consists of a 1 1/4-in. square bar 14 in. long

suspended by I-beam monorail and having a dog on one end to hook coils; this bar is driven forward and back by motor operated pinch rolls with a speed of 30 rpm.; the pinch rolls are driven through worm reduction by 12-hp. dc. motor. Dimensions: center line of vibrator to center line reels 88 ft. 9 5/16 in., center line mill to center line 4 ft. 6 in., diameter of collapsible cores 20 1/2 in., diameter of revolving top 3 ft. 9 in., diameter of pinch rolls 9 1/2 in.

Two muffle conveyors of the chain and dog type, located side by side, receive coils from reels and convey them through a partially deoxidized atmosphere and deliver them to trucks; the muffle effect is secured by water-cooled covered plates. At the end of main conveyor, short inclined chain conveyors lower the coils onto trucks; each conveyor is driven through gear reduction by a 12-hp. ac. motor. Dimensions: center line reels to the nearest conveyor 4 ft. 9 in., conveyors center line to center line 5 ft. 9 in., center line conveyors to center line of building columns 12 ft. 2 1/2 in. Speed of chain 350 fpm. Length of conveyor, center line of reels to center line of head shaft, 116 ft. 4 3/16 in.

Motor-Room.

The motor-room is located in the mill building on the east side, 260 ft. from the north end columns with a length of 140 ft. and a width of 43 ft. 9 3/4 in. The walls are brick and the roof is of corrugated sheeting, removable to admit crane hooks into motor-room. All mill driving motors, two 2,300-kw. motor generator sets, exciter, and a Spracco air washer are in the motor-room.

Electric Equipment.

The electric equipment is all furnished by the General Electric Company. The roughing stand and the intermediate stand are driven by two 1,250-hp. 175-350 rpm. dc. motors. The last four stands, which constitute the finishing mill, are each driven by 800-hp. dc. motors, with speed varying from 200 rpm. to 250 rpm. These motors obtain their power at 600 volts, dc., from two motor generator sets, type MCF 12, 450 rpm., 600 volts, 2,300 kw. compound wound, each driven by a 3,300-kva. 450-rpm. 220-volt motor.

CORROSION OF FERROUS METALS

A paper was read before the Institution of Civil Engineers, in which the author, Sir Robert A. Hatfield, referred to tests made with fourteen different types of ferrous metals. They included irons (rolled and forged), carbon steels, special steels, and cast irons, and were represented 1,330 separate specimens, 24 in. x 3 in. x 1/2 in.

The tests were carried out on a total number of 182 test-pieces, and particulars of the tests are given. The nature, chemical composition and other qualities were discussed, and in the case of non-rusting steel, the resistance to corrosion, when constantly wetted by sea-spray, depends upon its physical constitution.

The author discussed the various theories of corrosive action, and the addition of copper to steel, for the purpose of preventing or mitigating corrosion, was not generally advised. Examples were given of special steels possessing great resistance to corrosion, and specimens of historical interest were described.



Wheeling Steel Corporation Construct New Power Plant

A Detailed Description of the Modern Power Station Constructed at the Whitaker-Glessner Plant, Wheeling, W. Va.—Many Unusual Features Mark the Plant.

By THOS. G. ESTEP

Associate Professor Mechanical Engineering,
Carnegie Institute of Technology

A NEW power plant has recently been put in operation at the Whitaker-Glessner Plant of the Wheeling Steel Corporation at Wheeling, West Virginia. Engineers are always interested in how others have solved their problems but a description of the plant should prove doubly interesting to the profession on account of its many unusual features.

At the present time, and for some time past the mills of the Whitaker-Glessner Company have been undergoing complete reconstruction for the purpose of making them more modern and efficient and to greatly increase their capacity, the product being chiefly sheets and black plates.

This rebuilding and increase in capacity has made a new power plant necessary and the engineering features entering into its design and construction are based on the years of experience of the company engineers in meeting the needs for power, light and heat for this branch of the steel industry.

Location.

When a plant is located in a river town like Wheeling, one would naturally expect to find it situated on the river bank so as to secure all the advantages of a navigable stream; such as an abundant supply of water and water transportation for fuel. But this plant is some distance from the river—in fact—far enough away so that no benefits are derived from the stream. There are two reasons for this. First, due to railroads, etc., no space was available along the river bank. Although this first reason is conclusive enough, the second is equally good, viz., that the company has its own coal mine, the drift mouth being in the hillside above the boiler house. The advantage of having the coal delivered in the mine cars directly from the pit mouth to the coal crusher far outweighed any advantage that might be secured from a location near the

river, particularly when, for the present, the plant is to be operated non-condensing.

The site selected also has the advantage of being centrally located with respect to the mills so that long steam and transmission lines are avoided.

A part of the hillside, which is very precipitous, had to be removed to provide space for the buildings, and since this involved solid rock excavation, every possible advantage was taken of the topography in establishing the floor lines so as to have as little excavation as possible. A glance at the section in Figure 2 shows how this idea was carried out.

Buildings.

All the buildings are of steel frame work covered with corrugated galvanized iron. Practically all of this plant was constructed during the highest of the war prices, and although a brick building had been originally contemplated and designed, the cost at that time proved prohibitive and the cheaper construction was resorted to. The design is such, however, that the brick walls can be built at any time without any interruption to the operation of the plant.

The boiler room is 143 feet long and 58 feet wide with basement. The engine room is 100 feet long by 52 feet wide and is also provided with basement. The electrical repair shop which is under the same roof as the engine room and served by the same crane occupies a space 43 feet by 52 feet.

Boilers.

The boiler room contains four Connelley boilers having 8,290 square feet of effective heating surface and designed for a working pressure of 200 pounds per square inch gauge. The boilers are of the standard type with the standard location of baffles. An interesting feature in connection with the baffling is the

method of supporting the middle pass baffle. Instead of this resting on the regulation cast iron frame, a piece of extra heavy pipe has been substituted, which is patented, the ends of this pipe being open and extending out through the boiler walls. The free air circulation through the pipe prevents overheating and warping. If necessary, one end of the pipe can be carried up towards the top of the boiler, this producing a stack effect and securing more rapid air circulation.

The baffle openings are shown in figure 2 and are arranged to give best results when the boilers are operated at from 150 to 175 per cent of their rated capacity.

Boilers numbers 1 and 2 are fitted with Westing-

designed to give 100 deg. F., superheat at 200 pounds per square inch gauge pressure, when boilers are operating at 100 per cent of their rated capacity and the moisture in the steam does not exceed one per cent. This corresponds to a total steam temperature of 488 deg. F.

All boilers are fitted with Vulcan soot blowers, there being seven elements in each boiler. In addition to the regular cast iron sheathing, the elements located in the first pass are further protected from the high temperature gases by tile baffles.

The boiler settings are all covered with "Evertite" a plastic material used to prevent air leakage.

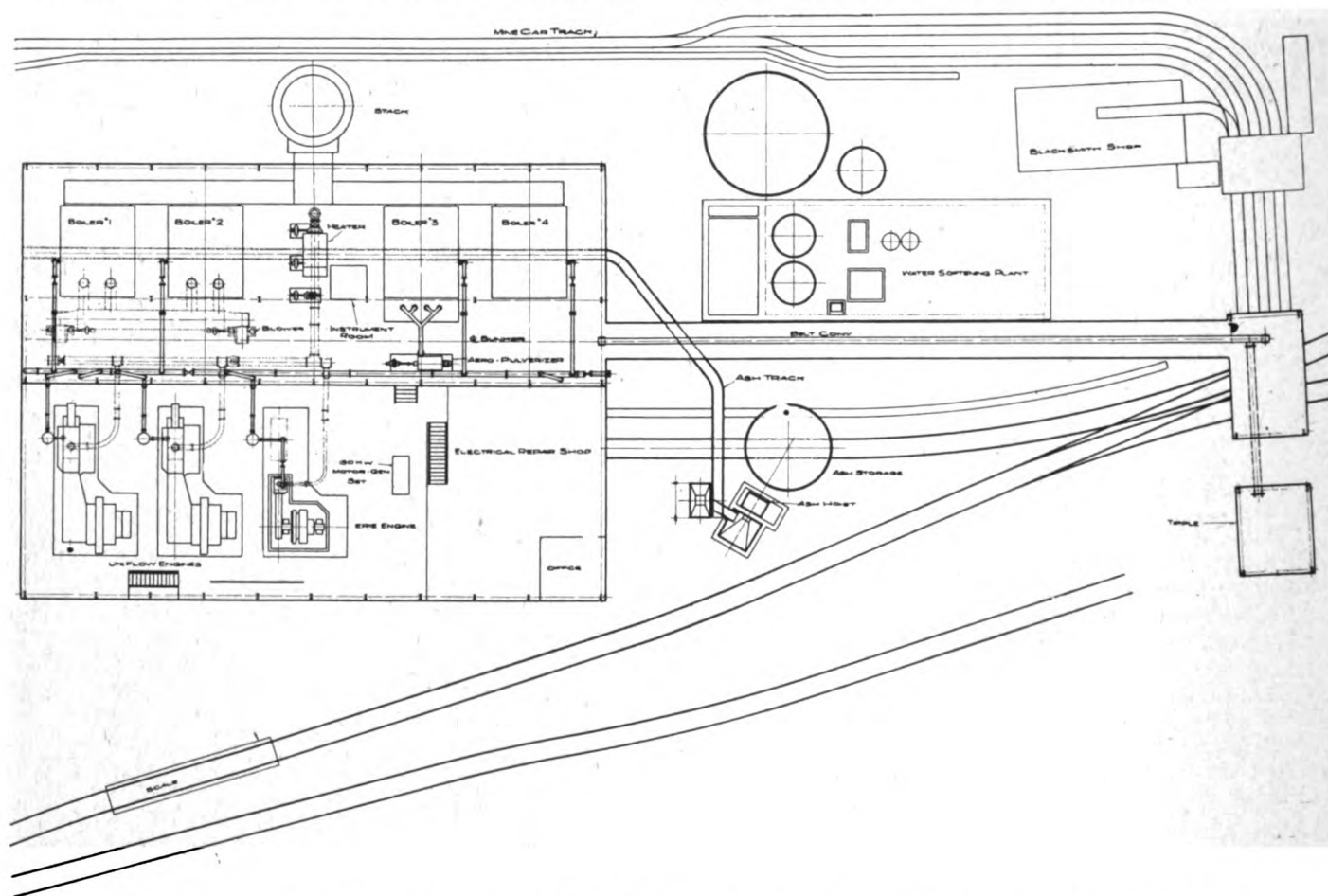


Fig. 1—Plan view of plant showing location of mine tracks, coal tipple, water softening plant and ash storage in relation to main plant.

house underfeed stokers having 8 retorts per boiler. The stoker drive consists of two Westinghouse engines arranged so that either engine can drive the two boilers, either separately or combined, thus insuring maximum flexibility. The stokers have an actual grate area of 153 square feet and a projected area of 142 square feet. This corresponds to a grate surface ratio of 54 and 58.3 respectively. The boilers are set well above the grates, the center line of the mud drum being 8 feet above the dump grates. This gives a furnace volume of about 2.2 cubic feet per rated horse power of boiler.

One boiler is equipped with the Drake non-clinker furnace lining which has proven very satisfactory. The boilers, however, have not as yet been operated at high rating for any great length of time.

Each boiler is equipped with a Foster Superheater having 1064 square feet of superheating surface and

Boiler number 4 has not been bricked in as yet, pending the results of the experiments with powdered coal now being conducted on boiler number 3.

There were no exceptional engineering considerations which lead to the selection of the above mentioned type of boilers, stokers and superheaters. At present the load on the plant is not very heavy and the system of operation is to operate one boiler continuously at from 150 to 175 per cent of its rated capacity and take care of the fluctuations in the load on the other boiler.

With number 4 boiler eventually bricked in and equipped with either powdered coal or a stoker, the capacity of the boiler plant will be sufficient to take care of the requirements for several years, with one boiler as a spare. No especial provision was made for extending the boiler plant in the near future as this is not contemplated.

Feed Pumps and Heaters.

A space between boilers numbers 2 and 3 was provided for the location of the boiler feed pumps, water heater and instrument room.

There are three Frederick centrifugal boiler feed pumps, direct connected to 50 horsepower Terry turbines. They have a capacity of 150 gallons per minute when operating at their normal speed of 2,800 rpm. Each pump can take care of about 2,500 boiler horsepower (maximum) so that two pumps will provide for about 200 per cent of the rated capacity of the three boilers. Conditions of operation are such that it is expected to have one pump in reserve at all time.

In the summer months all the exhaust steam from the engines and auxiliaries goes through the open heater. In the winter exhaust steam is used for heating the various parts of the power plant, the excess going to the heater.

Draft Apparatus.

Forced draft for the Westinghouse stokers is furnished by two turbine driven fans, operating at 1,700 rpm, the turbines being furnished by the Westinghouse Company and the fans by the Green Company. During the summer months the fans take air directly from the fan room, but in the winter when the fan room

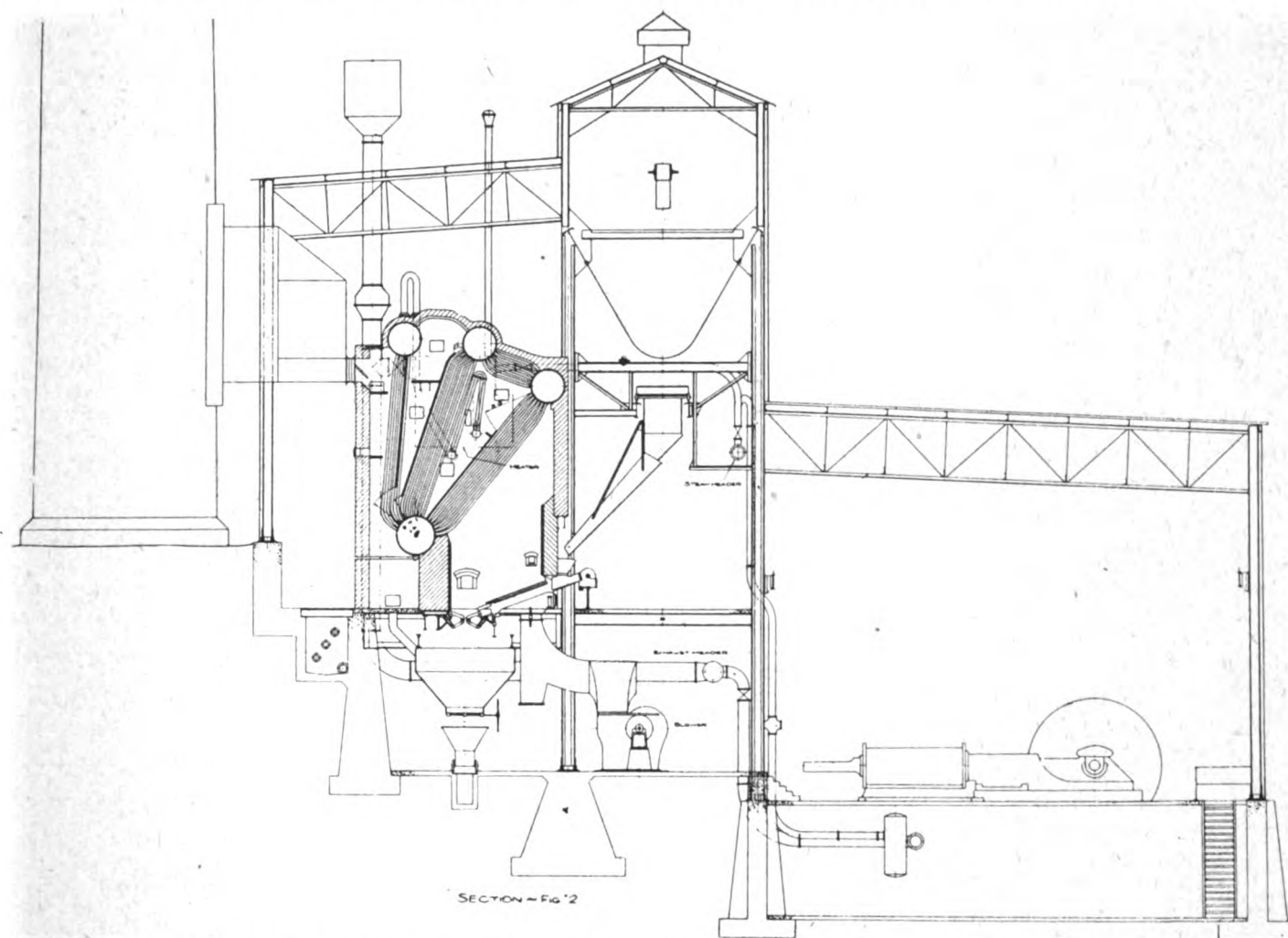


Fig. 2—Cross section showing how advantage was taken of the topography in establishing floor levels.

A Cochrane combined open feed water heater and "V" notch weir having a capacity of 225,000 pounds of hot water per hour is located directly above the feed pumps so that there is always a positive suction head of approximately 14 feet. The capacity of the heater is such that it will exactly supply the three feed pumps?

Installed in the main exhaust header line which is 24 in. in diameter is a Klipfel back pressure valve which is to be used for regulating the pressure to the Skinner heaters and the water softening plant for heating purposes. In the vertical line leading to the heater is a Cochrane multiport back pressure valve set so that the back pressure at the engine is about a pound or a pound and a half, just enough to force the steam to the heater.

must be heated, the air for the fans is taken from the outside, a single suction duct serving both fans.

Each fan has sufficient capacity for two boilers and they are connected in such a way that either fan can serve either boiler or both boilers.

Space has been provided for the installation of two similar units for boilers numbers 3 and 4 for which stokers have been purchased, however, if the powdered coal turns out as anticipated two of the stokers will not be installed. Natural draft is furnished by a brick chimney 14 feet inside diameter at the top and about 200 feet high above the grates. The chimney was built by the H. R. Heinicke Company. The plan view of the plant shows the location of the chimney with reference to the plant.

Coal and Ash Handling.

The coal and ash handling equipment was furnished by Webster Manufacturing Company.

The coal comes from the pit mouth to the coal tippie in the mine cars and is dumped onto a screen, the fine coal going directly to an apron conveyor, the lump coal passing to a two roll Heyl & Patterson motor driven crusher and thence to the apron conveyor. This conveyor discharges the coal on the belt conveyor which carries it up and into the coal bunker.

The coal handling equipment has a capacity of 60 tons per hour. The belt is 18 inches wide and about 670 feet long. It travels at the rate of 250 feet per minute and rises $3\frac{7}{8}$ inches in 12 inches or an angle of about 18 deg. The total rise of the belt conveyor is about 50 feet. The bunker, which is steel, bitumastic lined, has a capacity of 700 tons and by doing some hand shoveling the capacity can be increased to 800 tons.

The coal is spouted from the bunker to a traveling weighing hopper where it is weighed and the weight recorded. After weighing the coal is spouted to the stoker hoppers.

The ash and clinker from the boiler furnaces drop into a fire brick lined cast iron hopper provided with a water sprinkler which can be operated either from the boiler room or ash tunnel floor level. This ash

hopper is provided with poke holes and explosion doors.

The ash drops through a hand operated gate into a side dump buggy which holds one cubic yard. This buggy is then taken out through the ash tunnel into the yard by means of a Mercury electric locomotive operated by storage batteries and the ash is dumped into a pit covered by a coarse grid with 12-in. square openings. The ashes then pass from this pit through a hand operated gate into the skip hoist, having a capacity of 40 cubic feet, which delivers them into an ash storage bin of 5,900 cubic feet capacity, from which they can be spouted into railroad cars.

The cross section of the boilers shows a duct leading from the duct space back of the bridge wall to the boiler ash hopper. This is a circular duct and is closed at the top by a hollow 14 in. cast iron ball which can be rolled aside and the dust removed. When the ball is in place air leakage is prevented when ashes are being removed from the hopper.

Water Softening Plant.

The water softening plant was furnished by the International Filter Company and has a capacity of 27,000 gallons of treated water per hour.

Water from the city mains, which is untreated river water, is first treated with alum in the coagulating

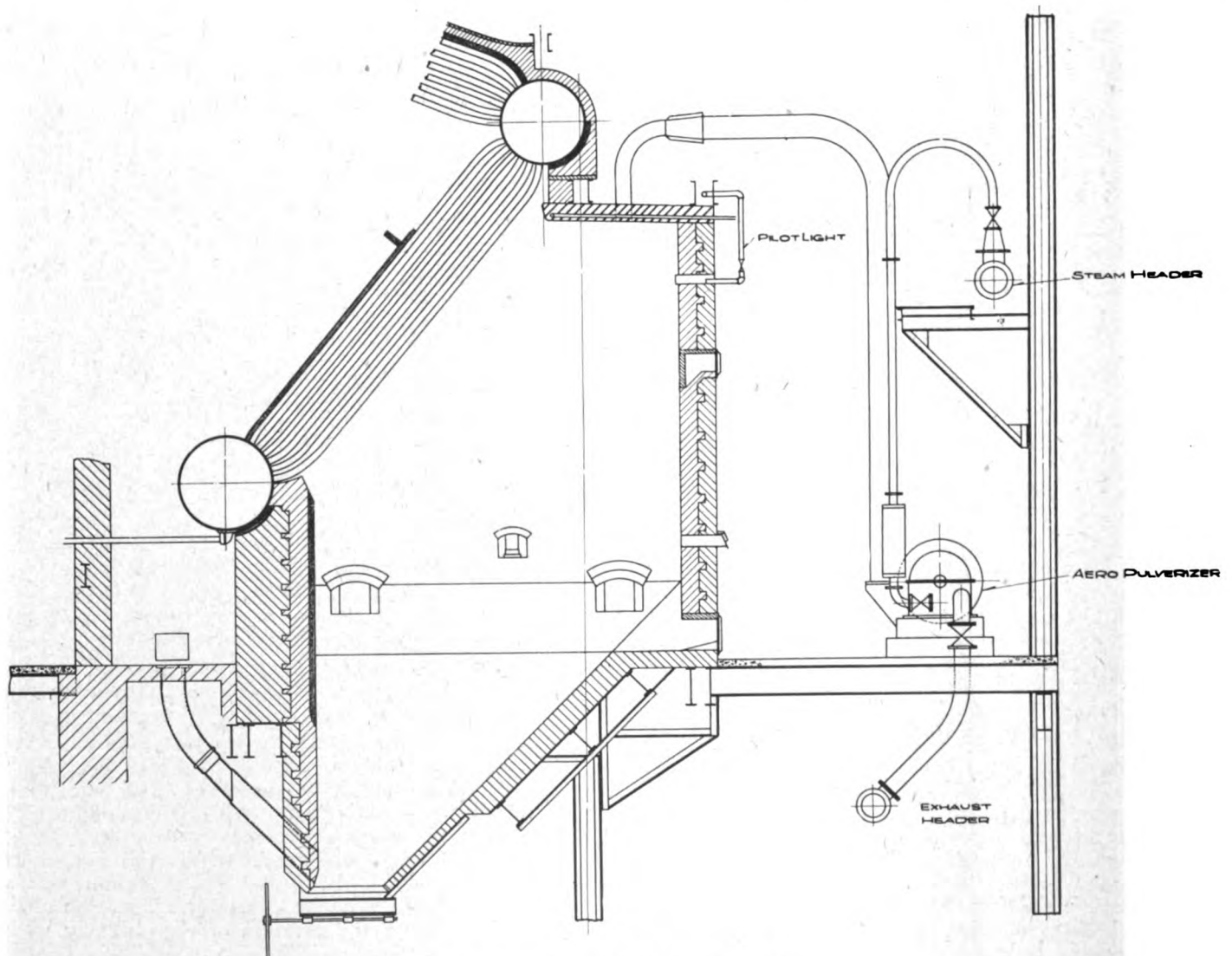


Fig. 3—Cross section of pulverized coal furnace.

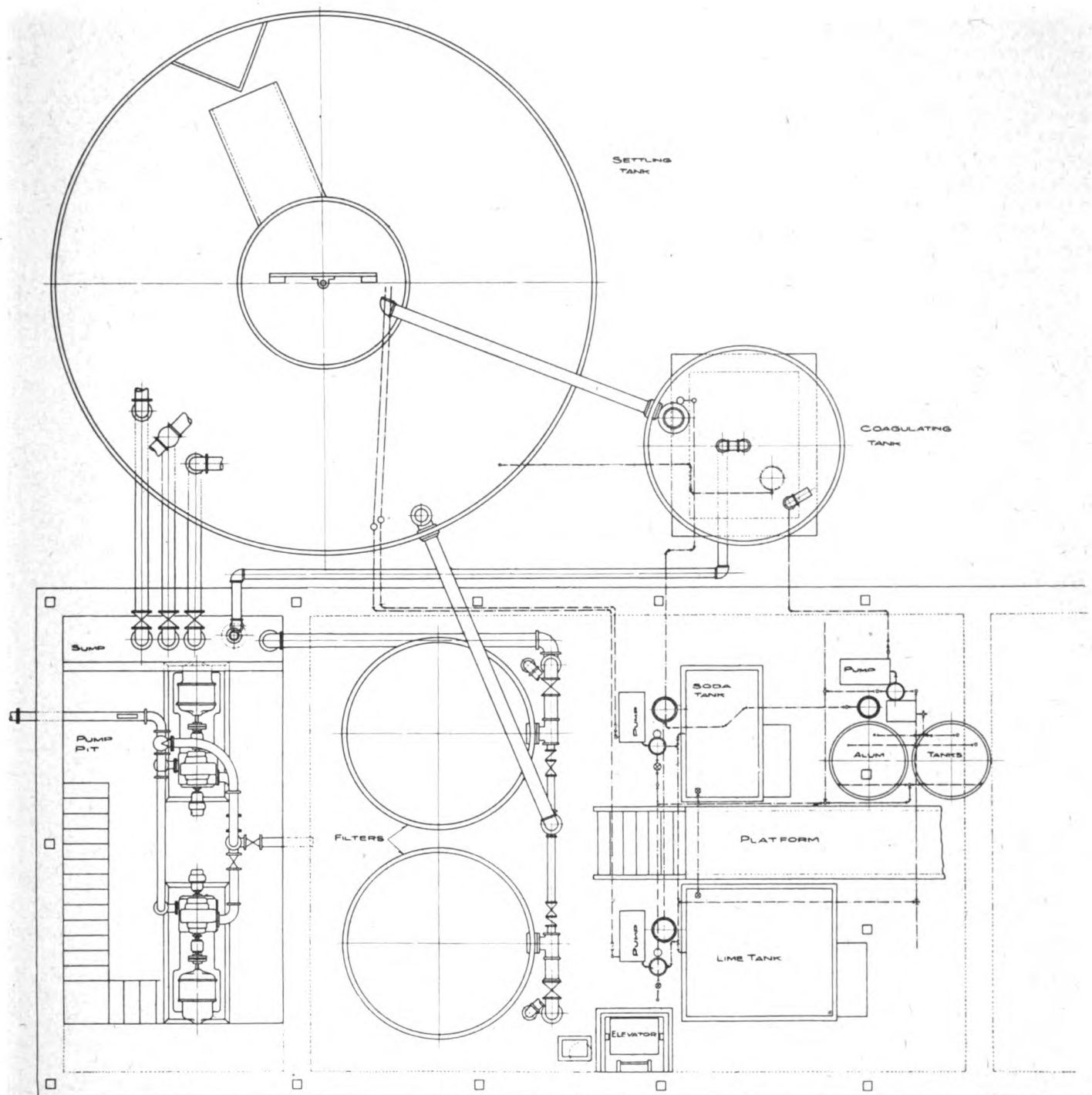


Fig. 4—Plan view of water softening plant.

tank which is 11 feet diameter and 22 feet high. The water from this tank is then treated with lime and soda and passes to the settling tank which is 30 feet diameter and 22 feet high. Water then passes from the settling tank through sand filters to the clear water basin which forms part of the softening plant foundation. The clear water basin has a capacity of 52,000 gallons.

In a pit at the base of the clear well are installed two motor driven 2 stage Worthington centrifugal pumps having a capacity of 300 gpm, each. These pumps are supplied under a positive suction head and deliver the water to the feed water heater, or when the heater is being cleaned or repaired, direct to the

boiler feed pumps. Since the clear water pumps have a capacity of 300 gpm., one is held in reserve.

The entire operation of the filtration plant is automatic. Tests of the treated water are made twice daily and changes made in the strength of the chemical solutions accordingly, but the proportioning of the solutions to the water is entirely automatic. The treatment is intermittent, a new batch of water being treated automatically as needed.

A small electric elevator is used to bring the chemicals from the car at the yard level up to the mixing platform. As the plan and sections of this softening plant show, every advantage was taken of the topography.

It proposed to install a 50,000 gallon storage tank on the hillside above the boiler room. The clear water centrifugal pumps will deliver water to this tank and will be controlled by a float so that their operation will be intermittent but at full capacity instead of continuous at reduced capacity as at present. The treated water will then flow by gravity from this new storage tank to the heater or boiler feed pumps.

Powdered Coal.

At the present time powdered coal for boilers is receiving a great deal of attention from the engineering profession so that a description of what is being done along this line at this plant will no doubt prove very interesting.

Figure 3 shows a cross section of number 3 boiler

The foundation of this boiler was built to receive a Westinghouse stoker so that the bottom of the combustion chamber was made to conform to this and no especial significance is attached to its shape.

Coal is spouted from the bunker to a size G Aero pulverizer having a capacity of 6,000 pounds of coal per hour. The pulverizer is driven at 1,450 rpm, by a Westinghouse turbine.

The coal from this pulverizer rises vertically in a single duct, passes over to the top of the boiler and enters through four branches.

In starting up the boiler, ignition is accomplished by using natural gas.

As before mentioned, this installation is still in the experimental stage and the work which has been done

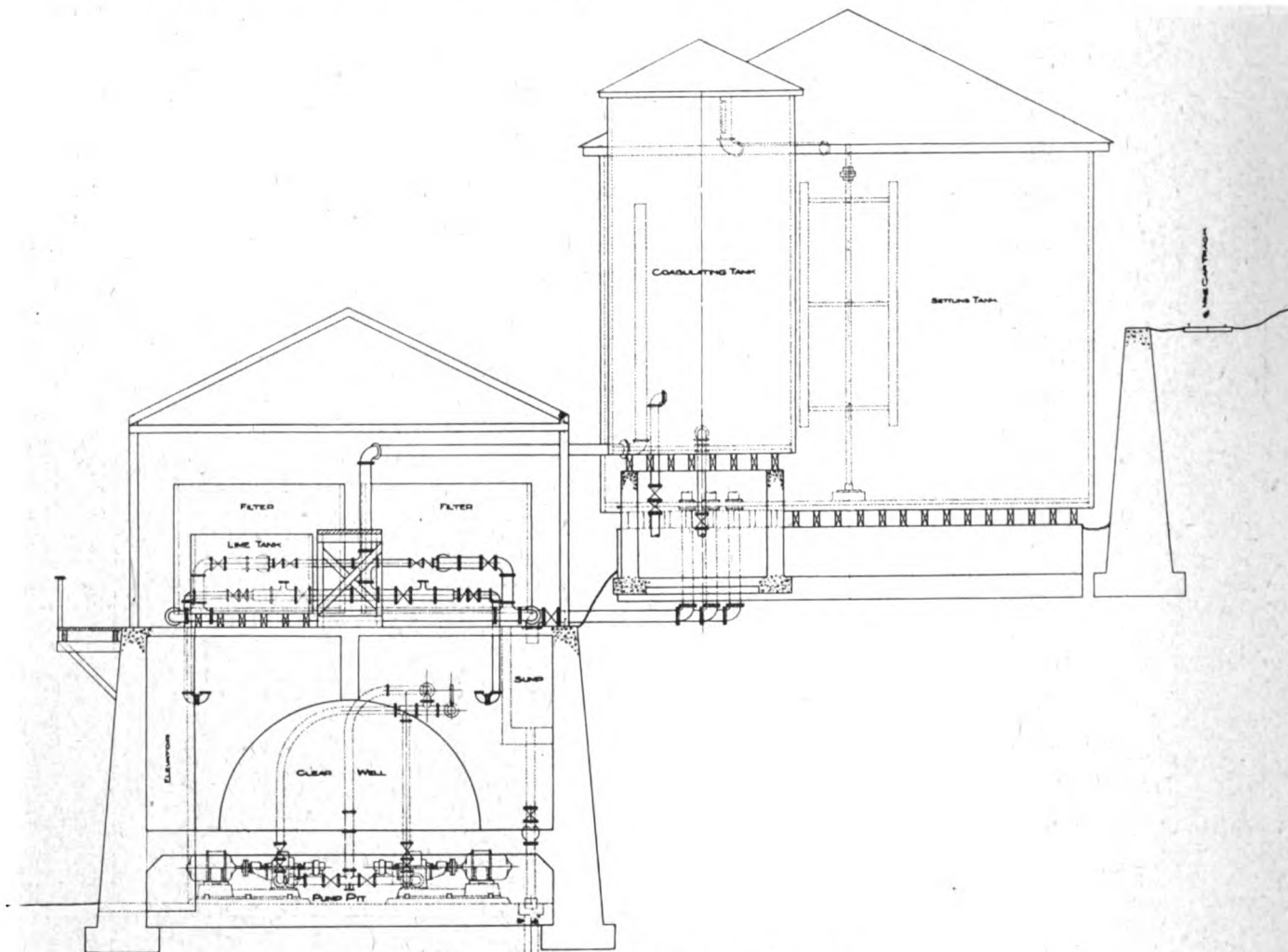


Fig. 5—Section of water softening plant.

as it is now equipped for the burning of powdered coal. It must be understood that this work is in the experimental stage and that the final arrangement may differ greatly from the present scheme.

The front wall of the boiler has been moved out about five feet in order to provide a large combustion chamber, giving a volume of over 5 cu. ft. per rated hp of boiler.

At the top of the combustion chamber is a water cooled flat suspended arch which is patented. Powdered coal along with the air for combustion is admitted through this flat arch in four places as shown, the fuel being directed vertically downward.

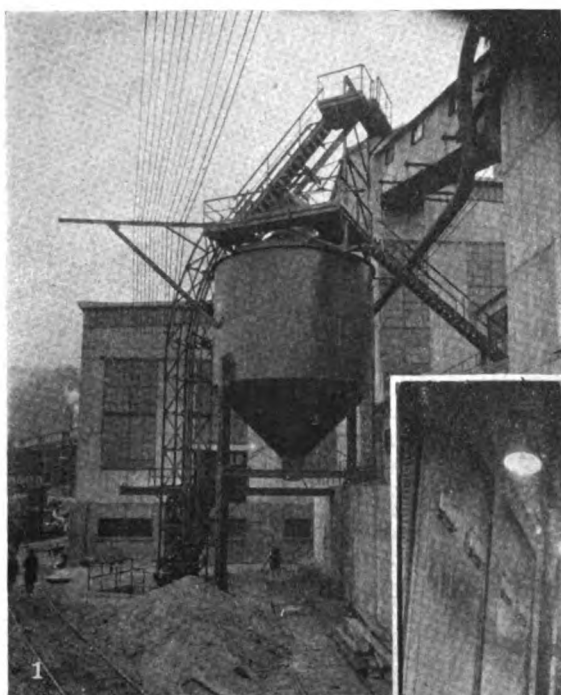
so far was of a preliminary nature so that no test data are available.

So far the performance has been, in general, very satisfactory. No serious trouble has resulted from slaging, the capacity secured from the boiler has been high and judging from flue gas temperature and analysis the efficiency is high. Minor details in the technique are being solved at present and it is hoped that test data may be available later to the readers of Blast Furnace and Steel Plant.

Engines.

The engine room contains two 24 in. x 42 in. Nerd-

berg uniflow engines operating at 125 rpm, and direct connected to 600 kw dc Westinghouse generators operating at 250 volts. These engines receive steam at 200 pounds per square inch gauge pressure superheated 100 deg. F., and exhaust against a back pressure of 2.5 pounds per square inch gauge.



There is also one old style, Erie City four valve engine, size 21 in. x 21 in., operating at 185 rpm, and direct connected to a 275 kw, 250 volt dc Crocker Wheeler generator.

The engine receives steam from the main steam header through a reducing valve where the pressure is reduced to 140 pounds per square inch gauge.

The Erie City engine had already been in service in the plant and was moved to its new location.

An interesting feature in this connection is that this small engine rests on a foundation already prepared for the third Nordberg uniflow, which will be installed when load conditions are such as to make it necessary.

In the engine room, there is also a Westinghouse 225 hp, mg, set supplying direct current at 500 volts for the mine locomotive and coal cutting machines.

The two wire system is used entirely. The switchboard contains ten power distributing panels and two lighting panels.

The engine room and electrical repair shop is served by a 10-ton hand operated crane.

Located in the steam line near the uniflow engines are large Cochrane receiver separators having a volume of about six times the piston displacement.

The main steam line to each engine is provided with a quick closing electrically operated Falls-Engine-Stop which is closed automatically by over speeding and can also be closed by push buttons conveniently located.

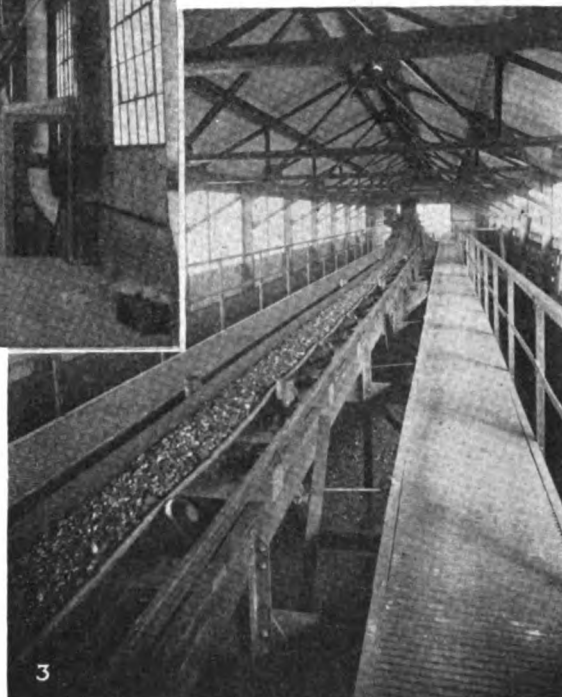
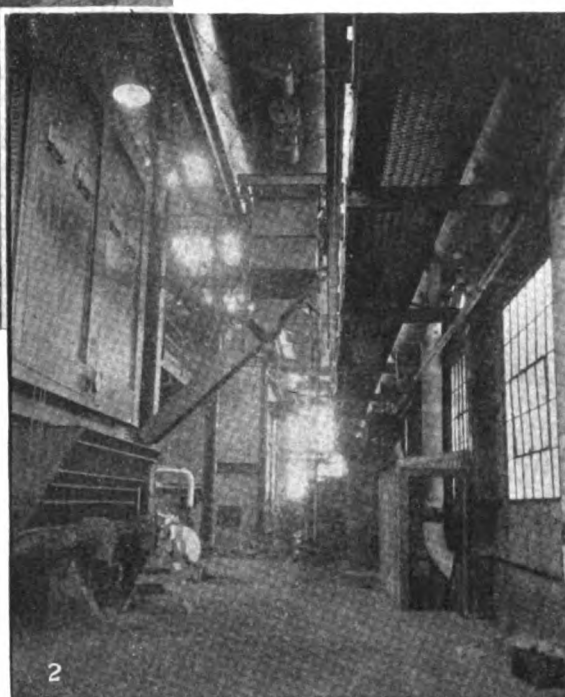
The considerations leading to the selection of uniflow engines instead of turbines or duo-flow engines was largely a matter of the final cost of power.

Whether superheated steam was to be used or not was decided by using guaranteed water rates for both saturated and superheated steam and figuring final power costs, an advantage was shown for the superheated steam. There was also the advantage of having dry steam in the long steam lines in the mill.

Several factors entered into the decision to operate the engines non-condensing.

The only available water supply at present is city water which is now comparatively cheap because it is raw river water. The city of Wheeling is now planning the installation of a filtration plant which will increase the cost of water. Keeping this in mind and considering the present size of the plant, the actual gain due to condensing was rather uncertain so that for the present, at least, it was decided to operate non-condensing.

With the advent of filtered city water, it is proposed to increase the pumping capacity at one of the other plants of the Corporation which is located at the river's edge and then this plant will supply raw water to the several plants in this district. When this is done and the third engine installed, the plant will be operated condensing.



Figs. 1-2-3—General views of Webster Manufacturing Company's coal and ash conveyor system installed in the Wheeling plant.

Instruments.

The electrical switchboard is equipped with the usual indicating and totalizing instruments.

Each boiler is equipped with the Bailey Boiler Meter giving the steam flow, air flow and stack tem-

perature on the one chart. In addition two porcelain scales are provided upon which are indicated the steam flow and furnace draft. This instrument is mounted directly on the boiler front for the use of the fireman.

An instrument room has been built in the boiler

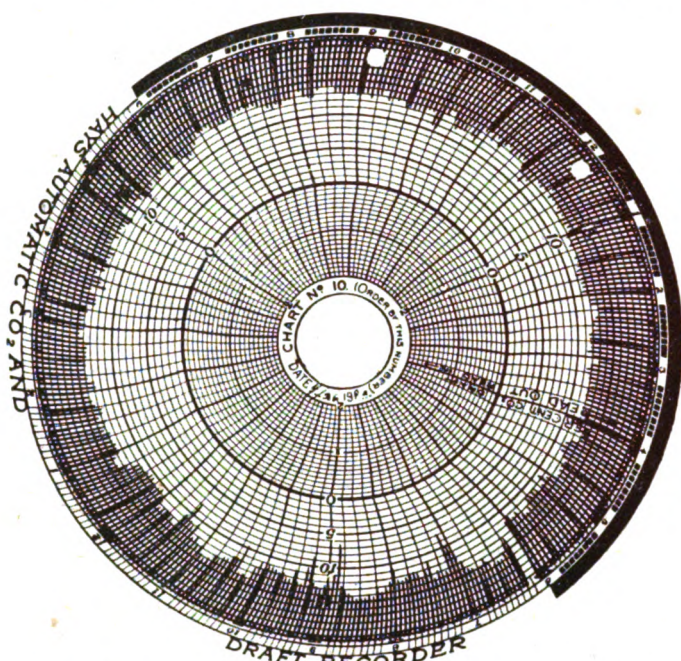


Fig. 9—Chart from the Hay's CO₂ recorder connected to one of the stoker fired boilers. Note the uniformity of the CO₂ content which indicates that the boiler is well managed.

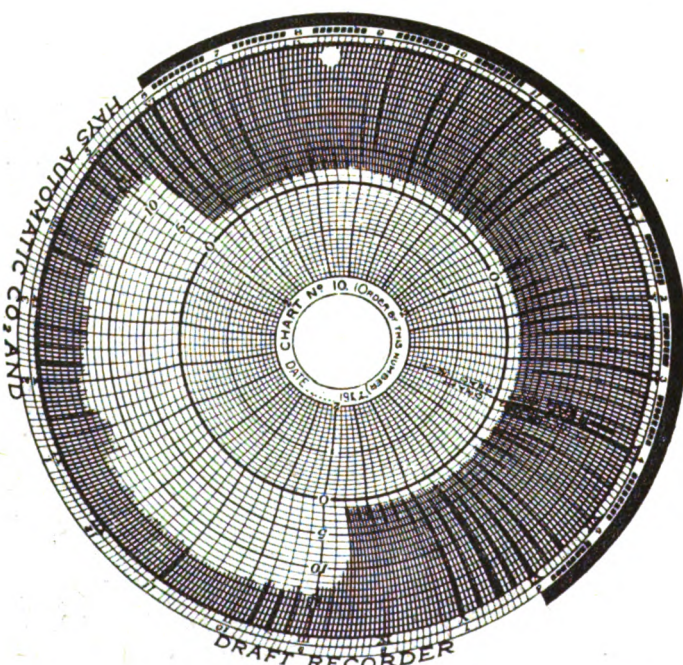


Fig. 10—Chart from the Hay's CO₂ recorder connected to the powdered coal fired boiler. The CO₂ content in addition to being high shows an average variation of only about one per cent which indicates remarkably efficient control.

room in the space between boilers numbers two and three. Located in this room are the usual recording thermometers and pressure gauges.

The Hays carbon dioxide recorders are used, one recorder for each boiler.

Republic steam flow meters are used on the steam distribution lines to the engines and mills.

To secure satisfactory operation of the flow meters on the lines to the reciprocating engines, where there is a pulsating flow, a thin plate orifice, having an area of 80 per cent of the area of the steam line was placed between the special pitot tube and the engine. This orifice, along with the large receiver separators reduced the pulsations enough to make reasonably accurate measurements possible. The indicating and recording devices of the Republic meters are also located in the instrument room.

The Carrick Combustion Control is used on all of the boilers. This control is actuated by a change in the steam pressure and varies the speed of the stoker engine, the position of the boiler damper and the amount of air supplied by the forced draft fans. This

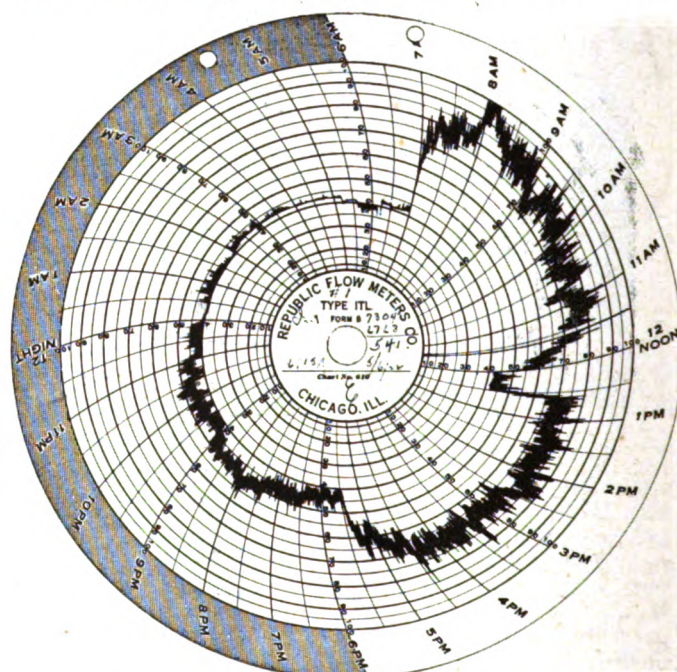


Fig. 11—Chart from the Republic Flow Meter on the main steam line to the Uniflow engine. This engine carries a fluctuating load which accounts for the width of the record line. By the use of a throttle disc and a large receiver, pulsations have been almost entirely eliminated.

latter quantity is changed by a damper in the air duct rather than by changing the fan speeds.

It was felt that better economy could be secured by operating the turbine at constant speed and varying the load than by changing the speed.

The method of control of the boiler burning pulverized coal may prove interesting. An auxiliary regulator actuated by the main regulator control dampers in the air supply to the pulverizer. This auxiliary regulator also controls the supply of pulverized coal by regulating the speed of the coal feeder. Another regulator, actuated by the furnace pressure, controls the breeching damper, maintaining a constant negative pressure in the combustion chamber.

Piping.

The piping layout was made by the company engineers and erected by the American Foundry and Construction Company. Bends were used wherever possible instead of fittings and Van Stone joints were used throughout. The covering was all done by the Johns-Manville Company.

There is one commendable feature in connection with the piping. There are no valves or fittings which cannot be conveniently reached, either from the floor or a gallery. The writer does not recall seeing a plant as well equipped with galleries as this one.

All drips and drains are taken care of by Bundy traps discharging back to the feed water heater.

An interesting feature in connection with the steam traps is that their operation was not entirely satisfactory at the full main pressure of 200 pounds per square inch, so that reducing valves were installed in the main drain headers where the pressure is reduced to 75 pounds per square inch. The traps now operate very satisfactorily.

All of the piping is painted, a definite color scheme being carried out so that the piping can be readily identified.

In putting this plant in operation it has been remarkably free from the various troubles incident to a new plant which only goes to show that a great deal of care and consideration was given to the selection and installation of equipment.

In conclusion, it might be interesting to note that a Nordberg twin uniflow engine has just been installed in the tin plate mill serving six stands of rolls. The engines are exact duplicates of the ones in the power plant, all of the parts being interchangeable.

Progress in Pulverized Fuel Firing

Code Recommended for Adoption by the Carnegie Steel Company
in the Handling of Pulverized Coal Presented—Many Points of
Unnecessary Danger Have Been Eliminated.

By F. J. CROLIUS

Steam Engineer, Carnegie Steel Company, Homestead Works

PULVERIZED fuel firing is moving forward steadily. The progress now being recorded will be permanent—as each year places a firmer foundation under existing knowledge structure; facts deduced from experience have taken the place of theories developed in enthusiasms.

Many claims have been made for the advantage of fuel fired in suspension over fuels fired in solid form, and not enough stress was laid upon certain disadvantages which were found to develop where excess temperatures are created and must be maintained continuously.

On the other hand, many conservatives were critics, and deservedly so, of any method which seemed less reliable than established stoker practice insured them—and had to be shown, not by a single unit over a short test period, with equipment handled by detailed experts—but by records of continuous performance on a production basis with equipment sturdy, simple, and reliable enough to compare with modern stoker installations, which operate very successfully with a minimum of skilled attention.

Today these widely variant viewpoints have been reconciled, have been brought together upon the common plane of dollars and costs results, for a given investment. Less discussion will be heard about efficiencies. High efficiencies will be accepted as *prima-facie*, and more stress will be laid upon the actual investment costs necessary to attain a given end.

A great deal has been written regarding cost of pulverizing coal, all of which is distinctly misleading when applied to boiler plant practice.

The procedure, in many cases, has been to make a detailed cost sheet, covering interest, depreciation, maintenance, power consumption, and labor, and then to add this total cost per ton to the price of coal, as delivered to the plant. The next step was to stretch the probably efficiency of the pulverized coal firing systems to more than make up for the cost of pulverizing coal, so that a favor-

able showing could be made in comparison with stokers.

This analysis completely overlooked the corresponding items of cost in a stoker installation which, when carefully analyzed, will be found to be about equal to the cost of a simple, well-designed pulverized coal burning plant.

Tests and operating results applying to the two methods of burning coal can, therefore, be compared directly, because, for every charge in connection with a properly designed pulverized coal system there will be an equal charge in a modern stoker plant. Pulverization cost must, of course, be carefully studied and important development work now in progress can be depended upon to reduce these costs considerably, but with the present state of the art it is not necessary to make any addition to the unit price of coal or to make any deduction from the pulverized coal efficiency before direct comparisons can be made with stoker fired plants.

Unfortunately, pulverized fuel had a tremendous handicap to overcome as a result of its various application to open hearth furnaces, where from its very nature it was and is not an ideal fuel. No discussion of the difficulties there encountered is necessary. They are too well known and understood to require mention.

Many points of unnecessary danger were allowed to creep into such installations, as well as into installations requiring numerous subdivisions from a central distributing system—such as small forge furnaces, sheet and pair furnaces, etc. Most of these dangers could have been avoided by careful attention to detail construction and operation, and will be in the future, as reference to the following code recently recommended for adoption by one of the largest industrial companies will indicate that such danger points are now recognized and *must* be guarded against.

Code Recommended for Adoption by Carnegie Steel Company.

1. A cloud of fine coal dust is as dangerous as a

body of unconfined natural gas if the dust is liberated where there is a fire or heat that would ignite gas.

2. Plants for crushing or pulverizing coal must be kept free from accumulations of finely pulverized coal that might be brought into suspension in the air.

3. Removal of accumulations of coal dust should be done by means of an exhaust system that will draw it through hose or piping and discharge it into a container without permitting it to again get into circulation with the air.

4. Buildings must be kept thoroughly ventilated at all seasons of the year when a pulverizing or crushing plant, or any part of one, is in operation.

5. Torches or open lights of any kind must not be used in any part of the plant at any time, whether or not the plant or any part of it is in operation.

6. Smoking within any enclosure where coal is crushed, pulverized or stored, must be entirely prohibited at all times.

7. Cleanliness must be strictly observed, and no accumulations of material of any kind, not necessary for present use in operating, should be permitted within any part of the plant.

8. Heat originating from any source that will raise the temperature of any material above 100 deg. must not be permitted in contact with a coal container.

9. Pulverized coal must not be permitted to remain in a packed or caked condition within piping or containers.

10. Heat of coal within a dryer, and after leaving it, must be perfectly controlled, and coal must not leave the pulverizer when its temperature is above 150 deg. F.

11. If a dryer is to be stopped for any considerable period of time, say five minutes or more, or if a dryer should unavoidably be stopped and it is evident the delay will be five minutes or more, should the dryer in either case contain coal—heat from the furnace must be entirely shut off or diverted so that none can enter the dryer.

12. At any time when combustion is in progress or the temperature of coal within a storage bin is about 180 deg. F., a fresh supply of coal must not be added. Such as is in the bin must first be removed and the bin cooled to normal temperature.

13. When the transfer of coal is to be stopped for any considerable period of time, coal in the transfer line must be entirely blown out.

14. Transfer of coal from pulverizing plant to points of consumption must be so positively regulated as to leave no opportunity for filling bins to overflowing; where a signal system is used, orders must be repeated and recorded. Where messengers are employed to arrange valves or carry information, they must report to the pulverizing plant in person before any coal is started forward.

15. When starting a fire in a drying furnace, paper or other light material that might be drawn by the draft into the dryer, must not be used for lighting.

16. Coal must not be admitted within a combustion chamber unless a flame of such proportions as will insure ignition at every point of entrance has first been placed before the burners.

17. When a pulverizing plant has been stopped for a considerable period of time that might be long enough for spontaneous combustion to begin, great care must be taken to avoid sending hot coal through a transfer line.

18. When coal is distributed by the continuous flow

system and used direct from the transfer pipe, great care must be exercised to prevent a drop of pressure in the transfer line below the pressure of secondary air injected at burners. Also where this system of distributing coal is in operation, at no time shall the quantity supplied to the transfer line be less than the maximum amount required for all burners that may be in operation.

19. If the transfer line should become clogged so that coal will not travel, the secondary air must be immediately shut off, and when the clog is removed, careful examination must be made to see that no particles remain in the line that could by any possibility start combustion.

20. Care must be exercised to keep burners open or keep coal from coking in them.

21. Conveyors or elevators should be kept tightly enclosed at all times.

22. Hatch lids of bins must never be opened while coal is entering the bins. They should not be opened unnecessarily, and they should be locked to prevent opening by others than those properly authorized to do so.

23. Motors installed within buildings must be inspected at intervals for deposits of dust within their casing.

During the last few years attention has been concentrated upon steam generation applications of pulverized fuels, and a new set of conditions has been discovered. Boilers are and must be automatically controlled units, which operate at relatively high thermal efficiencies. This is not true of metallurgical furnaces, where product is the major consideration. In boiler operation, furnace upkeep is a relatively small item of operating costs, and any great increase in this item will be quickly marked. This is less true in metallurgical furnaces, where brickwork destruction is a natural result of normal operations.

It took but a short experience firing fuels in suspension to develop the importance and necessity of specially designed and constructed combustion chambers. Much work has been done along this line, various methods of water-cooling and air-porting, various characters of high temperature, erosion-resisting, non-slagging refractories have been and are being developed. Ideal results are still in the future, but now that the condition is clearly recognized, it is merely a question of time before a satisfactory solution will be found.

One of the most interesting problems which pulverized firing seems to solve in a most practical way is that of combination fuels. This has always been an unsatisfactory operation at blast furnaces for instance, and at coke plants. Stokers do not lend themselves to this adaptation—pulverized fuels do.

The blast furnace becomes more and more a power plant with each passing year, as motor drives become practice in steel mills. Blast furnace gas is an ideal source of fuel supply, but blast furnace operation is none too uniform in its delivery of available surplus for power. Some auxiliary fuel must be supplied to maintain the power output constant, at least in average plants as now operated.

Pulverized fuel firing assumes the same characteristics as blast furnace gas, both as to combustion chambers and as to burners and air admissions. Either fuel can be cut off or cut in at a moment's notice. Charts taken from the operation at the most notable installation of this combination show but the slightest evidence of the frequent changes which are taken care of. Since ample combustion chambers are necessary for either

fuel, and where provided, very high efficiencies are being obtained at high ratings and with small operating crews.

A number of large installations at blast furnaces are now contemplated and the near future should show a marked development at such points.

One tendency in steam generation, shown particularly by stoker-fired central station units, which has not been followed up by pulverized fuel units, is extremely high over-ratings. Most of the pulverized units are operated at lower ratings than will satisfy the central station operator where 400 per cent no longer creates comment.

There is no reason, however, why the same tonnage of fuel cannot be burned under the same comparative boilers in one form as well as the other, and there is every reason to expect that such will be the case, and at much better efficiencies in suspension at those higher ratings.

The general tendency in pulverized firing is toward simplification of equipment. Definite conclusions have now been drawn that dryers may be eliminated—it being better economy to evaporate the moisture content in 99 per cent efficient boiler-furnace than in a 60 per cent efficient indirect-drier.

Elimination of the drier eliminates a real hazard, besides reducing costs.

Definite conclusions have also been drawn as to the extent to which fine grinding is essential.

What seemed like impossibly coarse coal is now being burned with complete success. This applies to bituminous coals only, however, and not to coke-braizes, or anthracites which must still be finely ground.

Coarser grinding is reflected in lower preparation costs, less power, lower repairs, lower overhead, less investment due to increased production of mills.

In many plants distributing systems have been eliminated and the direct-fired method is installed. The pulverizer is placed immediately at the boiler-furnace with direct fuel pipe supply to the furnace.

Such an installation involves a pulverizer unit as reliable as the boiler itself, more reliable than a stoker, a pulverizer which will handle wet coal, and operate continuously week in and week out on a low power consumption. Several such pulverizers have recently been installed under various types of boilers with capacities ranging from 1,000 hp. to 2,500 hp., depending upon the character of the coal supply.

One feature which this simple method of firing possesses is its susceptibility to automatic control, using existing control equipment in combination with the boiler which it supplies.

Not much attention has been given to this question of automatic regulation of pulverized firing, probably because of the extraordinary results of the excellent combustion obtained, but now that central stations are adopting this method of burning coal, in large, modern, specially designed units, regulation will inevitably assume the importance it deserves. The mere fact that pulverized combustion is so susceptible to careful control, and that very high efficiencies, between 80 and 90 per cent are demanded, will surely bring about this result.

It is far more difficult to control a screw-feed working in finely powdered coal due to its tending to flow, than a screw-feed handling raw coal.

Another feature of the direct method is the reduction in unnecessary spares, which will usually be found present where distributing systems are employed.

Should the average plant executive be asked to O.K. an appropriation request for *double* the stoker equipment necessary to develop a given boiler-horsepower, he would probably hesitate and ask for a revision of the estimate.

Such has been the practice where pulverizers are installed to operate during part time. The bins were filled during the short load periods and the pulverizers, driers, etc., kept idle during heavy load periods. Where the power required for pulverizing equipment is excessive, this practice may be justified—but a better solution will be found in equipment with very low power factor and great reliability.

Whatever develops will be quickly welcomed, for never was the interest in the general subject more sustained and widespread than at the present moment, when industrial recuperation indicates a great revival in power applications and in modernized power production.

CHEMISTRY AND PHYSICS OF GAS WORKS REFRACTORIES

Before the Midland Junior Gas Association, T. F. E. Rhead read a long and highly technical paper, in which the chemical and physical properties of the raw materials and finished products were expounded upon.

Refractory materials might be classed as acids, bases, or neutral bodies, but it was only with the acid refractories, comprising fireclays, siliceous clays and rocks, and silica rock and sand, that the lecturer was momentarily concerned.

Speaking of the properties of fireclays, it was shown that one of the most valuable was the absorption of water to form a plastic mass. The degree of plasticity depends upon the quantity of colloidal matter in the clay, and methods of increasing or decreasing this plasticity are given. A further important property of clay is its binding power. A correct rate of drying clay is very important; too rapid drying results in cracking, although shrinkage may be partly counteracted, by the addition of grog.

Continuing, the author explains the effect of heat upon the various constituents of clay, also on mixtures of clay constituents. A source of trouble in making alumina refractories, is the tendency to contract which alumina possesses. The addition of silica to alumina depresses the melting-point, whilst a jointing mixture of clay and silica will cause trouble. The refractoriness of clay is also reduced by the reaction of Fe_2O_3 (found in clay) and lime, which form easily fusible compounds at 1,200 deg. C.

The addition of grog gives the finished article a more porous texture, enabling rapid change of temperature to be withstood without cracking. The quantity to be added, however, is limited by the fact that the strength of the refractory is reduced.

The author then speaks of the various properties of fireclay and silica bricks. With silica bricks, the larger the proportion of tridymite and cristobalite, the better the brick will prove in use. At high temperatures, porous bricks are better heat conductors than those of dense texture. A strong point in favor of the silica brick, is the fact that it will stand a greater load when hot, than firebrick. The strength at high temperature is controlled by the adjustment of the proportions and sizes of the ingredients.

Follansbee Bros. Co. Operate New Steel Unit

The Modern Steel Plant of the Follansbee Brothers Company at Toronto, Ohio, Now in Operation—Designed Especially for the Production of Open Hearth Steel Sheets.

THE new plant of the Follansbee Brothers Co., manufacturers of sheet steel and tin plate, was recently put into operation and is a fine example of a modern mill designed especially for the production of high grade open hearth steel sheets. This plant supplements the company's older operation at Follansbee, W. Va., where the company commenced the manufacture of sheet steel and tin plate in 1904. The business has grown to such an extent that the Follansbee mill now has an annual production of over 60,000 tons of finished steel, and the Toronto mill was made necessary through increasing business. Its capacity is similar to the Follansbee Mill.

The new plant is located just below Toronto, Ohio, adjacent to the Ohio River and on the main line of

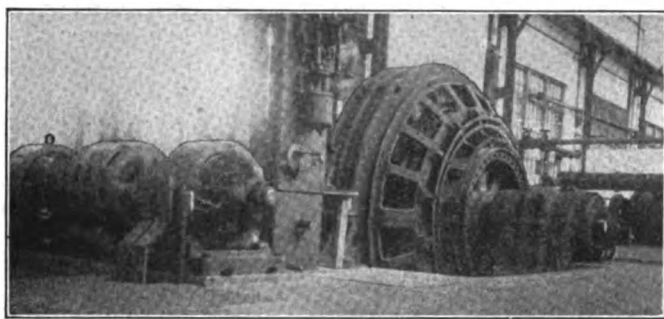


Fig. 1—View of motor, exciter set and main circuit breaker.

the Pittsburgh and Cleveland branch of the Pennsylvania Railroad, where excellent facilities are assured for the transportation of raw materials and finished product. It is probably the first plant of its kind to be electrically driven throughout, power being received from the company's own power station adjoining the plant. An abundant supply of water is available and coal will be supplied from the Company's mine adjoining the property. Provision is also made for the receipt of outside coal when desirable.

The mill site is graded and filled so as to be above the highest water level of the Ohio River. The site is peculiarly well adapted to a mill of this type, as the ground is level and admits of future additions at a minimum expenditure. The property adjoins the electric traction line to Steubenville and East Liverpool. On its forty acres the Company has erected to date ninety-six brick houses for its employees.

The equipment consists of four 40-ton open hearth steel furnaces, four ingot furnaces, one 15-ton steam hydraulic press, one 30 in. reversing bar mill, ten hot mills, four being 50 in., three 44 in. and three 40 in., sheet and pair furnaces, two Dressler Continuous Annealing Kilns. In addition there are the various shears,

cranes, and smaller apparatus usually found in a mill of this type. There is also a complete carpenter shop, machine shop and store room. Particular attention has been paid to the handling of material for the various processes and the mill is furnished with a large number of electric cranes, manipulators, etc., to facilitate rapid handling. Special provision was made to obtain maximum storage of both raw and finished material with a minimum requirement of labor in handling it.

Various types of fuel will be used according to the practice which has been developed by the company in the past. The open hearth furnaces will be fired either with oil or producer gas, the gas being supplied by a producer house containing eight Hughes Automatic Gas Producers. Coal from the mine will be conveyed to the power plant by a belt conveyor approximately 1,000 ft. in length, or can be received in hopper bottom cars from the railroad tracks adjoining producer house and power house. The coal is crushed and elevated to an overhead storage bin from which it is fed to the producers. The sheet and pair furnaces are fired with powdered coal prepared in the powdered coal plant housed in a separate building. A Flinn & Drefflein Gas Washing Plant with a capacity for thoroughly cleaning the gas from any two producers adjoins the producer house. This will furnish gas for the annealing ovens, drying ovens and other special purposes.

The electrical features of the mill conform to standard practice but also contain some special features of interest. Each group of sheet mills is driven by a 1,500 hp Allis-Chalmers Induction Motor through a Falk Herring Bone Gear set with suitable fly wheels for smoothing out the peaks, a liquid slip regulator being part of each set. The bar mill is electrically driven by a 5,000 hp maximum rated Westinghouse Reversing Mill Motor with a speed in either direction of 0 to 100 rpm. The mill motor is of the general reversing type, operating on 600 volt direct current and receiving its current supply from a fly wheel motor generator set. The motor, exciter set and main circuit breaker are shown in Figure (1). The bar mill is of the same design as that in operation at the Follansbee plant but electric drive was decided upon in place of the steam engine drive at Follansbee. The reversing motor is installed in a separate room with a removable door between the motor and bar mill. Located in the same room is the exciter set, motor-generator fly wheel set, slip regulator and control apparatus, two General Electric Motor-Generator Sets for supplying 250 volt direct current to the cranes, manipulators, etc., and the necessary 2,300/200 volt transformers for mill lighting, etc., are also installed in this room. It is served by a crane to facilitate handling of repairs. The power cables are carried from the power house to the mill over a structural steel bridge. This

bridge also carries a high pressure steam line supplying the forge press, gas producers, mill heating and heating of the company houses some distance from the mill.

Power Plant.

Of particular interest is the new power station built especially for this mill. It was aimed to obtain a maximum of simplicity consistent with good economy, this being especially desirable in a power plant serving a steel mill. Continuity of service is the one essential characteristic and only a short delay in the mill operation will soon offset small economies obtainable in the

each of which is connected to an independent brick stack 8 ft. dia. x 175 ft. in height, allowing for a short and inexpensive steel plate breeching directly into the stack.

Three turbine driven draft fans, one for each battery, are located in front of the boilers on the boiler room floor and furnish air for the stokers. Each fan has a maximum capacity of 44,000 cu. ft. of air per minute against a static pressure of 7 inches water gauge at a speed of 1,600 rpm, which is sufficient for two boilers at 250 per cent rating. Each fan discharges into a common concrete air duct running the full length of the boiler house. The air duct has sectionalizing

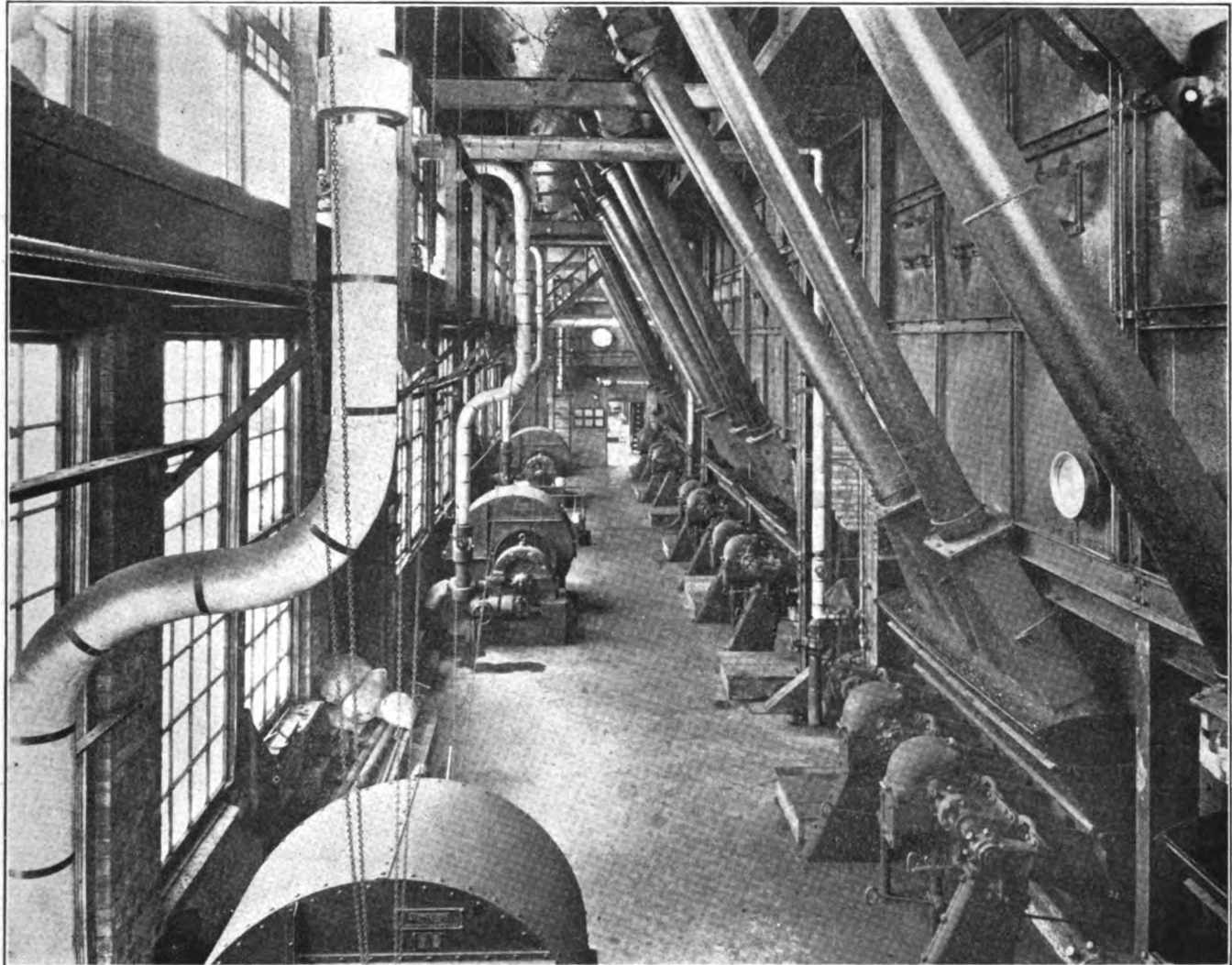


Fig. 2—View through boiler room.

public service plant through extreme refinement in design. A view through the boiler room is shown in Figure two (2).

The Boiler Room contains six 600 hp Badenhausen Water Tube Boilers with superheaters designed for operation at 200 lb. steam pressure and 100 deg. superheat. Each boiler has 6,000 sq. ft. of heating surface, is served by a six retort Westinghouse Under-feed Stoker, and is provided with mechanical soot blowers, feed water regulator, steam flow meter, and Precision Draft Gauge. Under normal conditions they will operate at approximately 175 per cent of rating. The boilers are set two in a battery forming three batteries,

gates so that any battery of boilers with its corresponding fan may be operated as a separate unit or a fan may be shut off entirely through a gate in the fan outlet and the boilers supplied with air from the main air duct. In this way any boiler may be served by whatever fans are in operation. Each pair of stokers is driven by a separate engine and so arranged that any engine may drive any stoker. If desirable two boilers, one stack, one fan and the stoker engine becomes a single operating unit. The location of the draft fans on the boiler room floor insures the proper oversight for continuous operation. The turbines are

likely to receive greater attention than when located in the basement. The boilers are set with the lower drum 7 ft. above the boiler room floor resulting in a large furnace which is desirable for carrying high ratings and efficient operation. The boiler settings are arranged so that there is an observation door in the bridgewall and the floor is dropped down behind the boilers so that these doors are accessible to the firemen.

Coal and Ash Handling.

The chief source of coal will be the Company's mining operation adjacent to the mill. It will be crushed

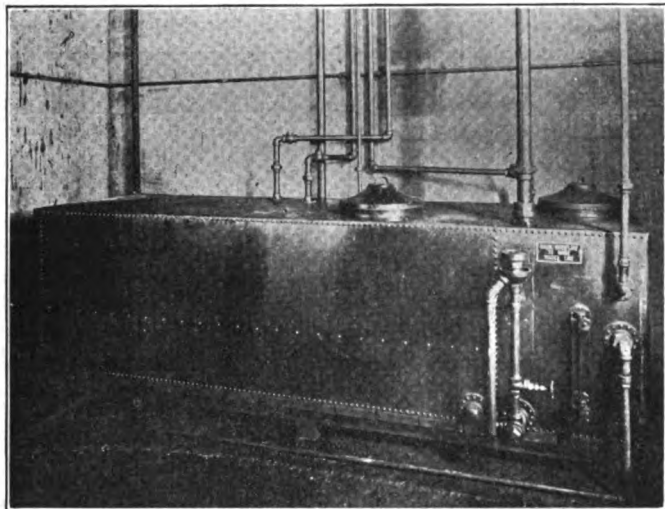


Fig. 3.

and weighed at the tipple and transported to the power house on an elevated belt conveyor and discharged to the storage bins. The power house coal bunker runs the full length of the boiler room. It is a steel bin with a capacity of about three hundred tons, or sufficient for 36-hour runs of the power house. Coal is distributed to the stoker hoppers through individual gates and chutes, two for each boiler.

Each boiler foundation includes a large ash hopper with sufficient storage for an eight hour run. Each hopper is furnished with a heavy cast iron rack and pinion gate with two openings, each 30 in. x 36 in. From the hopper ash is dumped into side dump steel cars running on a track in a tunnel under the boilers. At one end they are dumped into an automatic skip hoist which discharges the ash into a brick ash bunker outside the power house. Ashes may be removed from the bunker either by railroad car or by truck. A large amount of filling is required in the neighborhood of the plant and trucks will be used for some time. The ash tunnel has a clear height of over 6 ft. and is well ventilated to permit of comfort for the ash handling men. A dust chute from the back of each boiler discharges into a similar car underneath the boiler room and this car is dumped into the same skip hoist and carried up to the ash bunker.

Turbine Room.

Electricity is generated at 2,300 volt, 60 cycle, 3 phase by three high pressure condensing steam turbine units, two of 3,000 kw rating at 80 per cent power factor and one at 1,500 kw at 80 per cent power factor. The turbines are designed with a special overload nozzle so that a correspondingly greater load can be carried at any power factor over 80 per cent. It is

expected that the average load will be between 4,000 kw and 5,000 kw and will be taken care of by the two larger units, the small one being held in reserve for days when the mill is not in full operation. Should one of the turbine units be shut down for repairs it will be possible to carry the mill load with the remaining two units. Excitation is furnished by two separate exciter units, one of which is motor driven and the other driven by a non-condensing steam turbine. Ventilating ducts from the outside carry air to the turbo generators.

The oiling system for the turbine units is worthy of note and was furnished by the S. F. Bowser Co. Inc. The oil from the units is discharged into a large receiving tank in the basement and from there pumped to a filter tank equipped with duplicate pumping units located on a mezzanine floor in the turbine room. It is then filtered and distributed to an overhead storage tank from which it flows by gravity to the turbines. The receiving tank is large enough to accommodate the entire oil supply of the largest turbine units so that if it is desirable to empty the oiling system of one of the large turbines it can be done without waste or

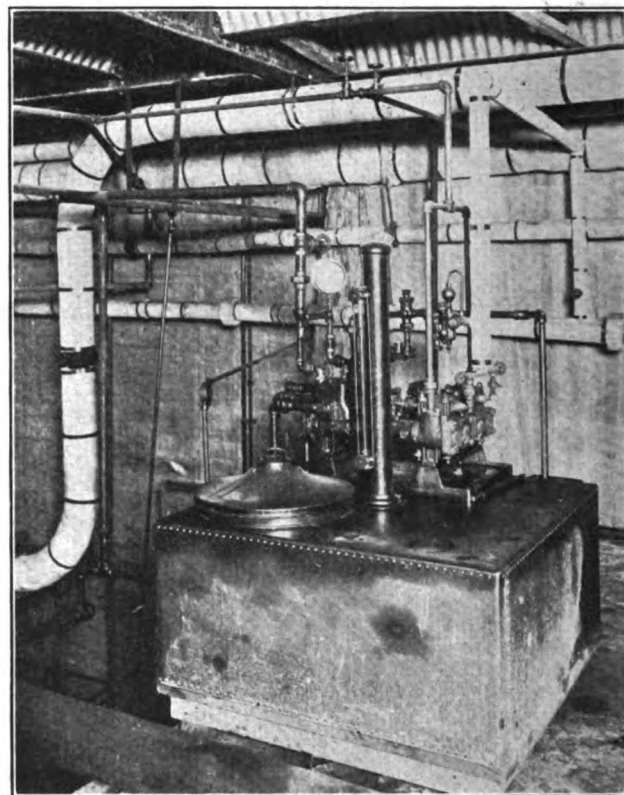


Fig. 4.

inconvenience. Figure three (3) shows the Filter and Figure four (4) the receiving tank with automatic water separator in the basement.

The main units are served by surface condensers located directly underneath the turbines. Circulating water is furnished by motor driven centrifugal pumps in a house built in the river, each condenser having its own circulating pump and water lines. The piping in the pump house, however, is so arranged that any condenser may be taken care of by either pump. In the suction line of each pump is an Elliot Twin Strainer and the inlet to the pumps is in a forebay of the pump

house which is furnished with removable trash racks. The pumps may be operated by automatic starters from push button stations in the power house or by an operator at the pump house. The air pumps are of the steam ejector type with an auxiliary condenser for reclaiming the steam used in the ejectors. Steam driven condensate pumps handle the condensate to the heater. For non-condensing operation the main turbines may discharge directly to atmosphere through individual atmospheric relief valves and exhaust lines.

Boiler feed water is obtained principally from the turbine condensate and heated in a 4,000 hp Webster Open Feed Water Heater. The heater is installed on a mezzanine floor in one corner of the turbine room with the turbine driven boiler feed pumps directly underneath. The heater is furnished with an indicating V notch meter for recording the flow to the boilers. Exhaust steam from all the auxiliaries is carried into the main exhaust line under the floor and up to the heater. Heat balance will be taken care of by operating the required number of steam driven auxiliaries. Ohio River water is used for makeup, provision being made for proper treatment of the make-up supply.

Particular pains were taken with the piping of the station. All high pressure steam piping is extra heavy with steel valves, monel metal fitted. Long radius bends have been used extensively and wherever feasible welded joints have been used in place of fittings. All valves throughout the entire plant are accessible through suitable galleries. The piping in the power house was furnished and installed by The National Valve and Mfg. Co. of Pittsburgh.

It is expected that the over-all economy of the power plant and electrically driven mill will be such as to show the decided advantages of a central station and electric drive, both from the standpoint of economy and ease of operation. The fuel consumption per ton of finished product should be considerably less than in a combination steam and electrically driven mill.

The design and construction of the new plant was under the supervision of Joseph Breslove, Consulting Engineer, Oliver Building, Pittsburgh, and C. W. Kinter, Chief Engineer of the Follansbee Bros. Co. The special features are based on long experience in manufacturing high grade qualities of sheet steel.

The Alabama Company's No. 1 Stack Breaks Production Record on Low Fuel Consumption

Production Increased 17 Per Cent, Coke Consumption Decreased 30 Per Cent—Labor Force Reduced 50 Per Cent.

By H. R. STUYVESANT
General Superintendent Blast Furnaces

THE improvements on No. 1 Gadsden stack together with the expected benefits derived from said improvements, was fully described in the May, 1921, issue of *The Blast Furnace & Steel Plant*.

No. 1 Stack was blown in October 10th, 1921. The increased production, and decreased fuel consumption is far above expectations. Actual operating data for the month of March is shown in table No. 1. During the first half of March the average daily production was 261 tons of foundry iron on 2,795 pounds of coke per ton of iron, while the average for the month shows 245 tons of iron on 2,820 pounds of coke per ton of metal.

Taking into consideration working volume, slag volume, yield quality of coke, working on special grades, no scrap used, and no off iron produced, this is considered remarkable performance and is due to the fact that the furnace lines and distribution was corrected, together with successful practice. The success of the operating is due to the fact that the operator strives for uniform operation, giving the highest production combined with the lowest fuel consumption, obtaining the highest quality product with the greatest possible economy. The evidence of highest quality

product is based on the fact that during the present campaign covering a period of six months including the blow in, the furnace has produced but two casts of iron running over .049 per cent sulphur which is only .002 per cent of the total six months production.

Table No. 2 shows actual monthly operating data including blowing in period. In referring to table No. 2 it might be well to keep in mind the following facts: First, the coke used from October the 10th to February the 20th was dirty unscreened coke. Chemically varying in ash content from 12.50 to 15.89 per cent and physically varying from 58 to 70 in friability, or hardness. Second, the wide range of silicons required for the special grades. Third, to the frequent complete burden changes required for the different brands of iron produced.

The Southern Pig Iron and Coke Association concludes that a furnace should burn sixty pounds of coke per twenty-four hours for each cubic foot of working volume, assuming a base coke with the following chemical specifications, fixed carbon 89.00 per cent, ash 9 to 10 per cent, volatile matter 1 to 2 per cent, and sulphur 1.00 per cent and under. Regarding the physical structure of this base coke, the adapted standard

reads as follows: It should be tough, but not dense or friable, and free from braize.

Table No. 3 shows No. 1 Gadsden stack on a comparative basis while (A) of this table shows theoretical data according to the established associations ratings, using the base coke and base theoretical yield on a furnace the size of No. 1 Gadsden stack which has a working volume of 10,838 cubic feet. (B) of table No. 3 shows actual operating data on No. 1 stack for the month of March. It might be well to mention the fact that the physical structure of the coke used during the month of March was not up to the standard adopted by the association. (C) of table No. 3 shows theoretical data on No. 1 furnace assuming the coke used to be the same as that shown for plant No. 3, table No. 4. While (D) of table No. 3 shows theoretical data on No. 1 furnace assuming same coke as that of plant No. 3, table No. 4, together with the base theoretical yield of 51.50 per cent. In looking over table No. 3 keep in

mind that (C) and (D) of table No. 3 were calculated, assuming as a base the actual practice on No. 1 furnace for the month of March, and during this month the coke used was not up to the physical standard adopted by the association, whereas if it were the actual practice, (B) table No. 3, as well as comparative data (C) and (D) would correspondingly show increased production and lower coke consumption.

While the majority of the Southern plants have low grade ores and high slag volumes to contend with, in referring to table No. 4 you will note the majority of the plants are favored with good coke both chemically and physically. Table No. 4 shows a comparative report on chemical and physical analysis of blast furnace cokes used at the different operations in the Birmingham district. The names of the different plants are not given, but are designated Nos. 1 to 5.

Foundry cokes of good physical and chemical qualities are also produced in the Birmingham district.

TABLE NO. 1

The Alabama Company's No. 1 Furnace—Average Blast Furnace Practice Month of March, 1922
Working Volume 10,838 Cubic Feet

Working on special grades ranging from 1.50 to 4.00 Silicon

Date, March	Average Daily Production, G.T.	Pounds per ton of pig Coke	Slag Volume Ave. Month	Analysis of Iron Sil. Sul.	Ave. Coke Ash	Ave. Ore and Scrap Yield	Cubic ft. Air per Pound of Coke	Pounds of Coke burned per cubic ft. working Volume	Tons Iron produced per 100 cu. ft. working Volume
1	279	2707	2200	2.05 .018	13.83	37.10	54	66	2.58
2	252	2997	...	2.26 .022	...	...	...	...	2.34
3	254	2973	...	2.77 .023	...	...	...	...	2.35
4	263	2961	...	2.72 .018	...	...	...	...	2.43
5	258	2973	...	2.60 .024	...	...	...	...	2.38
6	277	2641	...	2.07 .022	...	...	...	...	2.57
7	239	2962	...	2.30 .020	...	...	...	...	2.21
8	264	2458	...	2.28 .025	...	...	...	...	2.43
9	276	2693	...	2.26 .026	...	...	...	...	2.56
10	279	2516	...	2.04 .025	...	...	...	...	2.58
11	267	2673	...	2.10 .021	...	...	...	...	2.47
12	264	2637	...	2.31 .021	...	...	...	...	2.43
13	240	2853	...	2.08 .022	...	...	...	...	2.22
14	252	2889	...	1.88 .028	...	...	...	...	2.34
15	252	3002	...	2.56 .024	...	...	...	...	2.34
Ave. 15 days	261	2795	2200	2.28 .023	13.83	37.10	54	66	2.41
Ave. month	256	2820	2200	2.35 .023	13.83	37.10	54	66	2.35

TABLE NO. 2

The Alabama Company's No. 1 Furnace—Monthly Practice
Working on Special Grades

Ranging from 1.25 to 4.00 Silicon

Month October 10th to 31st Including blow in	Year	Average Production Gross tons	Average analysis of Iron Sil. Sul.	Average Ore and Scrap Yield	Average Coke Ash	Pounds per ton Slag Volume Ave.	Number of days on different brands of iron requiring complete Burden Change
Oct. 10th to 31st	1921	173	2.45 .027	37.40	13.75	3438	{ Etowah, 21 days Clifton, 5 days
November	1921	235	2.42 .023	37.12	14.36	2957	{ Etowah, 25 days Clifton, 5 days
December	1921	246	2.65 .026	37.35	14.22	3081	{ Etowah, 26 days Clifton, 5 days
January	1922	252	2.38 .027	37.18	13.79	3026	{ Etowah, 25 days Clifton, 2 days High Phos., 4 days
February	1922	244	2.02 .024	38.02	15.15	2939	{ Etowah, 20 days Clifton, 8 days
March	1922	255	2.35 .023	37.10	13.67	2820	{ Etowah, 31 days
Average Nov. 1st, to April 1st,	1921 1922	247	2.36 .024	37.35	14.14	2976	2500

TABLE NO. 3
The Alabama Company's No. 1 Furnace
On Approximate Comparative Basis

Southern Ohio Pig Iron and Coke Association Rating	Cubic feet working Volume	Pounds of coke burned per cubic ft. working Volume	Pounds of coke burned per 24 hours	Foundry, Pounds of coke per gross ton of iron produced	Basic, Pounds of coke per gross ton of iron produced	Gross tons of Fdry. per 24 hours	Gross tons of Basic per 24 hours
(A) Coke							
Fixed Carbon 89.00							
Ash 9.50							
Theoretical Yield 51.50							
Pounds of coke per ton of pig	10,838	60	650,280	2300	2000	282	325
Foundry 2300							
Basic 2000							
(B)							
Actual Alabama Company No. 1, Month of March							
Coke 84.92	10,838	66	719,100	2820	2494	255	288
Fixed Carbon 13.83							
Ash 37.10							
Ore and Scrap Yield							
(C)							
Comparison Alabama Company, No. 1 with Coke 90.70 Fixed Carbon, Ash, 7.90 same as plant No. 3, Table No. 4, with 37.10 Ore and Scrap Yield.	10,838	61.67	668,418	2532	2206	264	303
(D)							
Comparison Alabama Company, No. 1 with coke 90.70 Fixed Carbon, Ash 7.90 Theoretical Yield 51.50.	10,838	61.67	668,418	2287	1961	292	340

TABLE NO. 4
Comparative Chemical and Physical Analysis of Blast Furnace Cokes
Birmingham District

Name of Oven..... Time carbonized, hours..	The Alabama Co. Semet Solvay 18	Plant No. 1 Koppers 20	Plant No. 2 Koppers 17	Plant No. 3 Koppers 19	Plant No. 4 Semet Solvay 34	Plant No. 5 Koppers 20
Physical properties—						
Shatter	69	70	70	70	72	70
Friability	68	69	69	72	73	71
True density	1.96	...	1.75	2.04	1.98	...
Apparent density	1.08	...	1.02	1.14	1.09	...
Porosity	45	...	42	44	45	...
Chemical analysis—						
Moisture	.18	.50	1.53	.25	.80	.50
Volatile matter	1.07	2.68	2.17	1.15	1.55	1.04
Fixed carbon	84.92	87.74	84.75	90.70	85.42	89.38
Ash	13.83	9.08	10.55	7.90	12.23	9.08
Sulphur	.80	1.10	.74	1.11	.68	1.10
Btu	12,280	12,929	12,718	13,044	12,388	...
Approximate available carbon	76.92	82.08	78.57	85.65	78.25	83.70

TABLE NO. 5
Comparative Report on Present and Past Furnace Dimensions and Practice

	Hearth diameter ft.	Bosh diameter ft.	Bosh angle deg.	Height of furnace	Stock Line diam. ft.	Daily average produc- tion	Kind of iron produced	Average pounds of coke per ton iron	Ave. coke ash	Physical condition of coke	Ore and scrap yield	Cubic ft. wind per minute
Average years 1918 and 1919	11'	17' 6"	74	79'	12' 6"	210	Foundry	4265	15.45	Clean double forked	37.30	36,000
Average Nov. 1st, 1921 to April 1st, 1922	12' 3"	17' 8"	78	79'	12'	247	Foundry	2976	14.14	Dirty Unscreened	37.35	28,000

the following shows the physical and chemical analysis of two of the best foundry cokes in the South.

Name.....	Brookwood	Searles
Oven.....	Beehive	Beehive
Time carbonized	72 hours	72 hours
Coal seam	Milldale	Searles

Physical properties—

Shatter	76	72
Friability	73	67
True density	2.26	1.91
Apparent density	1.07	.95
Porosity	53	50

Chemical analysis—

Moisture	.20	.50
Volatile matter	.90	1.35
Fixed carbon	88.57	86.62
Ash	10.33	11.53
Sulphur	.85	.87
Btu	12,624	12,473

The present and past dimensions, etc., of No. 1 stack as well as the average practice is shown in table No. 5. While the average daily production was in-

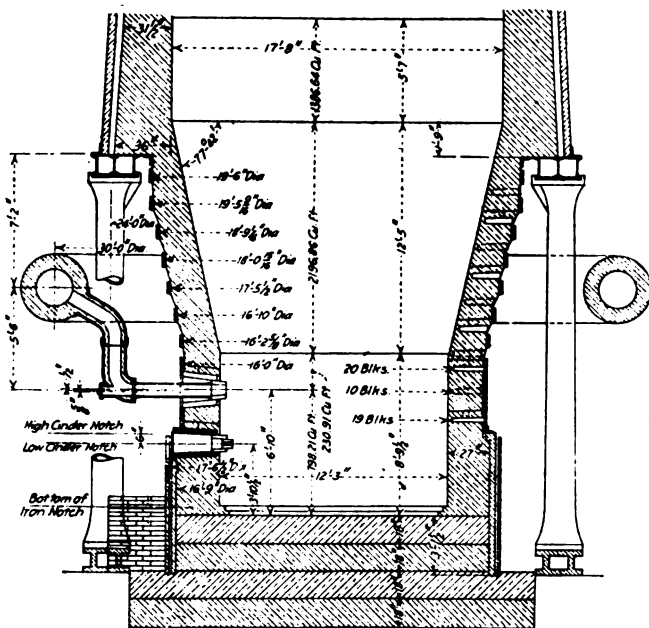


Fig. 1—Section through No. 1 Furnace.

creased 37 tons, the average coke consumption was decreased 1,289 pounds per ton of iron produced, or a saving of 159 tons of coke per day. Assuming the price of coke F.O.B. furnace to be \$5.00 per ton, the saving of coke alone for a year amounts to \$290,175.00. On the other hand manufacturing costs was materially reduced, owing to the fact that the labor force required to operate was reduced approximately fifty per cent, while the production was increased 37 tons per day.

With the idea in mind that uniformity and heat concentration is the secret of economical blast furnace practice, the company has now under plans to improve raw materials both chemically and physically in order to attain uniformity. With improved uniform raw materials production will be increased together with a decrease in fuel consumption thus lowering production costs.

CORROSION OF STEEL INVESTIGATED

A test of the resistance of chromium steels to acid corrosion recently completed by the bureau of standards, Washington, gives the information that the relative resistance of steel to the acid test is not necessarily a criterion of its behavior in other types of corrosion. Pure iron and steels of low chromium content were found to be much more resistant to attack by hydrochloric acid than those containing considerable chromium. However, when corrosion is caused by water and air, the general order of resistance was reversed. This led to the conclusion that the addition of chromium increases the rate of attack by hydrochloric and probably by other acids although this may depend somewhat upon the heat treatment which the steel has received.

Specimens hardened by heat treatment were found to be considerably more resistant to acid attack than samples of the same composition in the annealed state. The addition of nickel is more effective in reducing the intensity of attack by acid than is chromium, since steels containing a considerable amount of this metal were found to be the most resistant to acid of any tested. Specimens with a polished surface almost invariably showed a smaller loss in acid than those which were roughly ground. This difference may be only apparent, however, due to the fact that while the two specimens may have equal surfaces, the one with the ground finish has a slightly greater area exposed on account of minute grooves and ridges.

For resisting corrosion by water and air a considerable amount of chromium in steel is necessary and alloys of this general type were found to be more resistant than were those of low chromium content. However, these latter steels were more resistant than the simple carbon steel or pure iron. Hardening chromium steel by heat treatment retarded corrosion by water and air as it did in the acid test, this being true particularly for the steels of high chromium content, although variations in heat treatment produced little difference in resistance to corrosion in specimens lower in chromium. Adhering patches of oxide scale upon the surface produced a noticeable effect in accelerating the rate of attack in chromium steels.

The alloy containing a high percentage of nickel as well as chromium and found to be attacked the least by acid, also proved more resistant to atmospheric corrosion than most of the chromium steels tested although it was far surpassed by certain of the high chromium materials. In most cases, corrosion of the chromium steels consisted in an attack at small isolated spots rather than in a general tarnishing and coating of the surface. In view of the fact that adhering particles of scale accelerate the corrosive attack of a steel to a marked degree, this suggests that the presence of inclusions or other defects within the material may be responsible largely for the character of the resulting surface pattern.

Character of service should govern the type of non-corrodible steel to be used. For example, if resistance to severe acid attack is the principal requirement, a high chromium steel is the least suitable of all the materials tested. Most classes of service, however, require fairly satisfactory performance under a variety of conditions. For example, cutlery steel must withstand both acid and atmospheric corrosion as well as possess certain necessary mechanical properties. No single type of noncorrodible steel appears to be suitable for each and every purpose which may arise.

Fuel Economy of Steel Plants

Stenographic Notes of Paper Read Before the Blast Furnace Section of "Verein Deutscher Eisenhüttenleute," April 27, 1921, Published in *Stahl und Eisen*, December 22, 1921.

By DR. K. RUMMEL in Dusseldorf

Translated by Alfred Steinbart of the National Tube Company, Pittsburgh, Pa.

I AM very glad to have, at last, the opportunity to talk before the men who have charge of the operation of the blast furnaces. It would be a greater pleasure if I could convince these men of their own importance in connection with the whole plant, especially with the fuel consumption of the whole plant. The blast furnace has often been called the heart of the plant and not improperly, because it is a fact that the blast furnace propels the streams of material and power through the arteries of the plant giving vigor to the whole. It would be drawing the comparison too far, however, if we would say that the blast furnace man was the soul of the whole plant operation. This the blast furnace man generally is not, because he looks out first for himself and for his own department and you can hardly blame him for this. The blast furnace is a very touchy fellow—we all know that—who has to be treated with the greatest consideration and cannot be experimented with too much. It is, therefore, necessary to step easy in starting with changes at the blast furnace in order to improve the fuel economy of the plant as a whole, including steel works, rolling mills, etc.

The blast furnace gas—though it is the main source of power for our works—is and will always remain a by-product for the blast furnace man. The relative importance between the main product, the iron, and the by-product, the gas, may change somewhat, but it will never change so materially as it has changed in the coke plants where the former by-products really became the most important products and where the coke often is principally made on account of the by-products. But the blast furnace man likes to receive as much credit as possible for the gas supplied to other departments and it is generally the case that such credit is given. In connection with this subject, I would like to mention casually, that the government "Fuel Saving Commission" at Dusseldorf is of the opinion that the valuation placed by the works on the blast furnace gas is much too low and that more credit should be allowed to the blast furnace man for the gas supplied to other departments. (Applause.)

The gas should be paid for better, because it is worth more! Mostly it is paid for according to its heat value. For 1,000 Btu of gas one pays as much as one would pay for 1,000 Btu in coal. That is not right, because 1,000 Btu in gas are worth much more—except when used under boilers where the use of gas is more and more abandoned. Investigation shows that for use in gas engines and the different types of furnaces the gas is worth 25 per cent or 30 per cent more. Such a value might be an inducement to furnish gas to other departments.

Low cost per ton of pig iron should not be paramount. On the contrary, the blast furnace man should

feel as a member of the whole works community and he should fill his place in such a manner that the works as a whole is benefitted. There are yet today blast furnace men (those present, of course, excepted) who take a different stand. If the feeling takes root in you that you are principally a member of the whole works community, you will find it possible to improve a little here and there in order to help the fuel economy of the works as a whole.

If, with three blast furnaces working, the pressure of the gas varies from 9 in. of water down to 1¼ in., then it is time that something should be done. To our surprise, we have not found one single plant where an attempt was made, except by request, to determine the amount of gas actually produced by the blast furnace. You will probably be astonished by this statement because you all have gas meters. We have recently made the first attempt of this nature. The results are astonishing. Further investigations are still being carried on and I, therefore, cannot yet report.

We all know that the blast furnace cannot be made to furnish the gas in absolutely uniform volume. There are periods in which the volume of the gas changes, caused by changes and disturbances in the working of the furnace. Such changes cannot be avoided and the plant as a whole has to be prepared for them. But there are also several occasions where good management, anxious to keep up the supply of gas to other departments, can do much to keep the gas volume more constant. This, for instance, is the case during casting. The practice at most plants is to keep the blast on the furnace during this time. But the blast pressure varies at different works and it would be important to investigate how much pressure it is possible to carry at this time in order to avoid lack of gas during casting. In such cases where it is impossible to keep up the pressure, it may be advisable to increase the blast a little at the other furnaces so as to increase the gas production to cover the loss due to casting at one furnace. Several works have informed us that they do blow somewhat stronger at the other furnaces during the time when one furnace casts. This information is very important, because it shows—see also remarks in this connection later on—that the furnaces can stand more blast for short periods without interfering in any way with good operation.

We also believe that the stoves can be operated in such a manner that the surplus gas going to other departments remains uniform in volume, i. e.; the consumption of gas in the blast furnace department proper may be regulated to be more uniform. The replies from the different plants to our questions, however, vary very much, strange to say. At some of the works the changing of stoves causes a very marked dip in the record of gas consumption for the stoves. The reason

for this is that quite some time elapses from the point where the gas is taken off at one stove and turned on at the other stove. During this time no gas is used at one stove and the record shows a marked dip. At other words, however, this is not the case. We are now investigating this, but I recommended to you to look into this yourself in order to find the reason. One plant informs us that they are now endeavoring to shorten the time of changing stoves as much as possible. May be that it will be advisable to institute a sort of Taylor System in order to establish a manipulation of valves to shorten the time when the gas is off on a stove. Such attempts can but help to improve uniformity of gas supply over the plant as a whole. It may also be advisable to investigate if not a number of stoves in the plant are changed at the same time, so that a number of stoves are not consuming gas at one time. Further, we have found from the record of gas consumption by the blast furnace department proper, that individual stoves receive different amounts of gas for no reason whatever except that the stove man opens the gas valve more or less out of negligence.

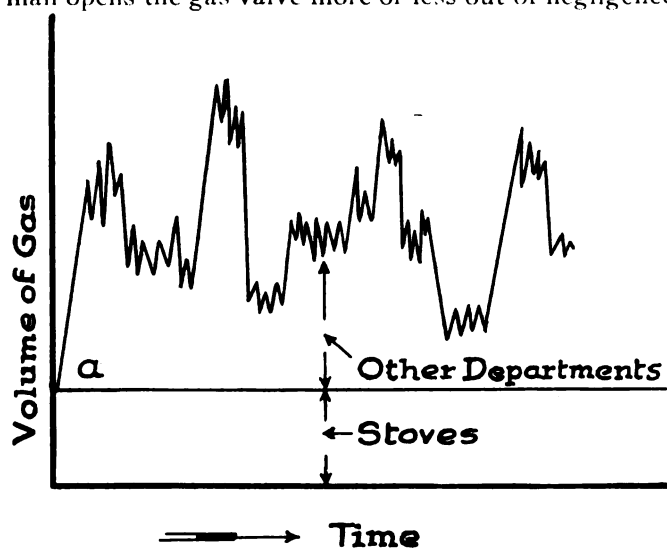


Fig. 1.

These appear to be small matters but they are very important when they result in gas variations of 35,000 cu. ft. per hour. It is, however, not only important that the gas is delivered uniformly to other departments but also that the blast furnace department absorb the irregularities of consumption of other departments. Most of you are probably very enthusiastic about the pressure regulators which are just now being installed at your gas mains to the stoves. I consider the installation of such regulators and the results at which you aim as entirely wrong.

See Figure 1. If you regulate the gas pressure and make it uniform so as to get good combustion and small gas consumption at your stoves, you make your gas consumption uniform. You cut off your gas consumption for stoves with a straight line (see a) at the bottom of the diagram. In doing this you do not in any way lessen the peaks but you simply eliminate them in your own department and throw them into the other departments. And not this alone; you make them far worse in the other departments. This, of course, is very convenient for the blast furnace man but not for the other gentlemen who have to take care of these peaks. I would like to state here, however, that it would be quite wrong to proceed now and install these pressure regulators also in the other de-

partments, because in this way the peaks would be left over and would have to be disposed of by bleeding. But I wish not to be understood that I condemn the gas pressure regulators altogether; on the contrary, they are very useful apparatus if they are used in their proper place. It appears to me, as the proper arrangement, that the blast furnace department try to work up the peaks in the diagram and that they endeavor to give the other departments the regular pressure because nowhere in the works have we such a storage for heat as is offered by the stoves. The stoves should be used as much as possible to store the peaks of gas because of their enormous storage capacity. The time is too short to go into this matter any further, but I will say this; that in order to use up the peaks in the stoves you must install an automatic regulation of the air at the stoves in order to adapt the air pressure to the gas pressure and so get good combustion with variable gas pressure. This can be done by using the above mentioned gas pressure regulator for regulating the air. Then you utilize the same apparatus to throw the peaks into the stoves.

In the last two years a good deal has been already accomplished on the lines pointed out above. There are already works who push their stoves harder at such times where gas is plentiful. There is one works where they work eight (8) hours in the rolling mills and shut down for four (4) hours; work eight hours again and shut down for four hours. During these four hours of shut-down the mill uses very little blast furnace gas. This time is employed to heat up the stoves. This shows that it is quite possible to follow the lines which I have pointed out above in quite some detail. Further, it is the practice to heat the stoves to a very high temperature on Sundays to store as much heat as possible. It is also the practice at some works where they use the "two stove method" to heat up the superfluous stoves on Sundays or at such times during the week when there is a surplus of gas, so that these energies can be utilized at time of demand. It is, therefore, very feasible to utilize the stoves for heat storage.

If you desire to furnish more gas to other departments you must also try to save as much gas as possible in your own department. This, I believe, is done now everywhere, and we have found, to our great satisfaction, that the gas consumption of the stoves has considerably decreased. While in the beginning, when we came around and took snap samples of your stove stack gases, we found often a large amount of air surplus or even carbon monoxide, we have not found this lately because this condition has almost ceased to exist on account of the practice of regularly making such tests and it is a fact that the consumption of gas in the stoves is much lower now.

Not only should gas be saved but also the blast conditions should be improved and savings made. Three methods can be used here:

First: Heat losses of the hot blast can be reduced. I would very much recommend to you to test the temperature drop from stoves to tuyers all along the line, because I am convinced that you will find places along this line where the drop is surprisingly large. We had similar experience in connection with tests on heating furnaces at rolling mills. If you improve the heat losses at these points by better insulation or otherwise, you cannot avoid making a saving. In some cases a thin cover of insulating material will help very much.

Second: And this is still more important—pressure losses of the blast should be avoided. Unnecessary pressure loss means loss of power. At most works, especially at the old one, the blast main show bends which are too short. I would recommend to measure the pressure loss at such bends and to eventually eliminate them if the pressure loss is too great. In connection with pressure losses, allow me to draw your attention to the by-pass line. Dr. Bansen, according to my knowledge, has been the first to point out the serious pressure loss sometimes caused by the same. This line is used to lower the temperature of the blast for regulating purposes and, as it winds through tight places around the stoves it is often made too small. In order to force sufficient cold air through this line it is often the practice to throttle a valve in the main line leading through the stove. This means a loss of energy which sometimes is quite large. I am satisfied that you will try to remedy this. But the fact that the throttling is being practised, and because less blast will enter the furnace at such time is a proof to me that it is possible to blow a furnace some times somewhat lighter without harm and that it is, therefore, feasible to vary the blast somewhat without interfering with good blast furnace operation. We have also learned, during the time of political strife, that it is much less harmful, than most of us thought, to reduce the blast. There are quite a number of plants where they reduce the blast on Sundays, because the blast furnace gas is so valuable for them. All this shows that the furnace will stand it all right to be used as an organ for regulation for the whole gas distributing system. In limits of from 5 per cent to 10 per cent at least, it can in some cases be utilized for the regulation of gas volume.

We have conducted, during the last weeks, tests with gas producers which have proven to us that they can be operated for a very variable production. The tests were made on slagging producers which were operated according to a predetermined schedule as far as gas production was concerned by changing the amount of blast to obtain the desired gas volumes. With the blast furnace, of course, nobody would go that far; but in certain limits regulation is feasible.

Third: The most serious loss, which often occurs through negligence, is the loss of blast through leaks. I do not exaggerate when I claim that some times from 30 per cent to 40 per cent of the blast is lost between blowing engines and tuyeres. To overcome this, I would recommend regular inspection of the blast mains, inclusive of all joints and flanges. There are only a few plants where such inspection is made regularly every month. Also you will find at each inspection that some repairs are needed at the bustle pipe, blowstocks, and blowpipes. If there is a leak of only a square millimeter, it must be attended to at once. In such case welding is often very convenient. Often much air is lost by leaky, cold, and hot blast valves. One of the works has built with good success double valves—one after the other—to replace the single valves.

The last point for saving of fuel which I wish to mention, is the spare blowing engine, which is kept warmed up in case of necessity and which costs in a year hundreds of thousands in steam. The Commission has strongly recommended to shut down these and install in their place fans which blow only a few inches of water and which are sufficient to start the furnace again after a complete shut-down.

Discussion.

Manager Jaeger—Bochum: Dr. Rummel stated in the beginning of his paper that we should attempt to blow more blast in order to avoid variation in the quantity of blast furnace gas. I believe that this is already being done for quite some time at all those works where it is necessary to pay especial attention to the supply of blast furnace gas for the whole plant. Regarding blast saving; would say that this point is of extraordinary importance. We have in our works at present a yearly loss of from two and one half million to two and eight-tenth million marks through blast leakage, notwithstanding that the losses have been reduced during the last few years about 15 per cent.

Manager Harr—Hoerde: Dr. Rummel has stated that credit given for surplus blast furnace gas at most works is too small. This is right without doubt. The question is—Why is this credit set so low? The answer is this—Because the quantities furnished are so irregular. The other departments of the works have to be so equipped that they can fall back at any time upon reserve apparatus. The blast furnace man cannot help this; he has to look out first for himself in order to keep his plant running properly and to avoid interruptions which might be more costly. Just on account of the great variation in the volume of the gas which can be furnished to outside departments the credit is so low and not as high as it really ought to be. I express the hope, however, that the day will come when we can make more uniform deliveries of gas. I, therefore, feel thankful that our attention has been drawn to various matters which will help us to make progress. Unfortunately, it is not possible for all of us to install such an enormous gas holder as the one installed at Ilsede. We have to do the best we can with our means.

The suggestion regarding the idle periods in the operation of mills is very good. I have heard from other plants that they are getting great savings in this manner. The idea is very obvious but I will tell you that it does not work with us. And why? Only because the men do not want to help along. The workmen still rule in a great many points. Not everywhere do they agree to a second turn after a pause of four hours. One turn would end at midnight or would begin at midnight. This is too inconvenient for the men. They even decline to work Saturday nights; therefore you will observe in passing our plant that almost every night enormous amounts of blast furnace gas are bled, burning like an enormous torch, while during the day we are short of gas. It is even worse in the night from Sunday to Monday, when, besides the blast furnace gas, millions of cubic feet of the valuable coke oven gas are bled because the gas holder has not sufficient capacity to store it.

We have tried, I do not know how often, to make it clear to our men what enormous National values are destroyed through their refusal. The labor leaders see it and admit it but their influence upon the masses is not sufficient to allow us to make better arrangements.

Manager Dr. Hartman—Ilsede: Dr. Rummel has told us that it is the duty of the blast furnace man to absorb in his own department the peaks; that means, the time at which there is a surplus of gas and that he should deliver to his colleagues in the other departments, which use blast furnace gas, the remaining uniform quantities of gas. Dr. Rummel also told us that

we could find a way to absorb the peaks by properly operating the stoves. That is true, and there are quite a number of simple means. For instance, we have an arrangement in Ilsede which shows in all engine houses and at all blast furnaces and, if necessary, also at each group of stoves, when a blast furnace casts or is checked. There is at all furnaces and at all engine houses, a box at a place where it can be easily observed. This box has as many pigeon holes as there are blast furnaces. The pigeon holes carry the number of the furnaces. The front wall of the pigeon hole consists of a tin plate in which the several blast furnace numbers are cut out. Behind this plate is a colored glass which is lighted by an electric light behind it and shows the number very plainly for a long distance. All these boxes are connected by wires. If one furnace casts, for instance, Furnace No. 4, then the blower at Furnace No. 4 sets the switch at his furnace and at all furnaces and at all engine rooms No. 4 is shown and also at all groups of stoves. This signal means Furnace No. 4 casts. Now it is not permitted to any other furnace to check. It is not permitted to change stoves and it means attention for the engineers at the engine houses and they watch the pressure. If the pressure of the blast, on account of checking of the furnace, increases at the other furnaces, then this will be only temporary and the other furnaces are getting more blast, as has been proposed purposely by Dr. Rummel. Of course, this only holds good in such plants where all furnaces receive their blast from the same blast header, as is the practice at our plant. The stove men are instructed to change the air supply at the stove burners according to the prevailing gas pressure. It is doubtful if they do this also always at night; at any rate I doubt it. But we obtain a certain amount of uniformity in the use of blast furnace gas at the furnace itself. This uniformity can still further be improved if the individual stoves for the several blast furnaces are changed on a time schedule; for instance—

Stoves of Furnace No. 1 are changed at
9:15 — 10:15 — 11:15, and so on

Stoves of Furnace No. 2 are changed at
9:30 — 10:30 — 11:30, and so on

Stoves of Furnace No. 3 are changed at
9:45 — 10:45 — 11:45, and so on

Stoves of Furnace No. 4 are changed at
10 — 11 — 12, and so on

In this way the change of stoves is distributed uniformly and if there are no other disturbances, we have a fairly regular gas consumption.

At the last visit of the Commission for Fuel Saving at Ilsede I have pointed out to these gentlemen that we have succeeded to quite some extent to use the stoves as heat reservoirs; that is, that we heat the stoves up to the limit as often as we can at such times when we have a gas surplus and that at such times when there is a great demand for gas in other departments we either do not fire any gas at all or but only very little at the stoves. I have shown these gentlemen that in Ilsede, during the time of greatest demand, 45 per cent and more of the total production of blast furnace gas was turned over into electric energy and that only 19 per cent to 20 per cent was left for heating the blast.

There is not a blast furnace man, I am sure, who will agree altogether with the proposals of Dr. Rummel and will be good enough to furnish to other de-

partments a most liberal and uniform volume of gas and at the same time suffer from lack of gas in his own department. The blast furnace man has to look out for his furnaces first and he has to have sufficient reserve at all times for all contingencies. I do not believe that this latter point can be changed.

Manager Zillgen—Wetzlar: I cannot follow Manager Hartman in what he meant regarding the uniform changing of stoves. I think it is necessary to maintain in the stoves a certain final temperature; therefore, I would not agree to change stoves at a certain predetermined time. I do not believe that we would obtain good results this way. We are making very extended use in other departments of blast furnace gas and we are absolutely of the opinion that the stoves are the best heat reservoirs and that they have to absorb the peaks and we are at it now to install gas pressure regulators for furnishing uniform pressure of gas to the other departments. We will also equip the stoves with differential-pressure regulators so that we will be in a position to regulate the air supply for the stoves to conform to the gas quantities when the gas pressure varies. We have already attained good results in trying this system and we have a much more regular pressure curve in the other departments than we had formerly.

Manager Schmidt—Oberhausen: In connection with gas economy, I would like to mention the following: Statements have been made here regarding the consumption of gas by the stoves which vary very considerably. The values vary between 18 per cent and 30 per cent. In our works we have lately paid much more attention to the economical use of blast furnace gas and we have accomplished a good deal. The blast furnace man has been given to understand that it is not so necessary to keep down the coke consumption as was the case in former years because we have been arriving at the conclusion that saving of coke is not the most economical thing to do for the whole plant. The result is that the blast furnaces are used to some extent now as producers, because we are not working any more with such high blast temperatures. This allows us to burn more coke. I would recommend to those works where they use only 18 per cent of blast furnace gas for their stoves to compare their blast temperatures with those of former years where the stoves used more gas and they will find that also their coke consumption per ton of iron has risen accordingly.

Dr. A. Wagner—Duisburg: I want to speak regarding the suggestion of Dr. Rummel to use the stoves as heat reservoirs for absorbing the peaks. I do not consider the use of the stoves for this purpose as ideal. It is a better solution if it can be done and as has been done, according to my knowledge, first at the Duisburg Copper Works. The best and most economical user of the peaks is the turbine. The peaks, which are the result of irregular consumption of gas, can be absorbed without any trouble by the boiler plants and turbines and the power can be taken care of through supply of current to the municipal power stations. According to my opinion, there is a very good field here for the fuel engineer and the central station engineer in particular. I have heard of a second case where Rheinische Stahlwerke have entered into negotiations with the City of Duisburg in order to turn over their surplus gas at their Works in Meiderich on Sundays. In return, the works of the company situated at Duisburg take current during the week

from the municipal plant and this current is partially paid for by the power supplied by the works. In most cases there would be no trouble to find buyers for current. I can very well imagine that, for instance, a city like Duisburg would shut down their central power station on Sundays and take all their current from the mills. Or, better still, that the mills would at all times be in connection with the city power station and give continually their surplus current to the city. Cities,

I believe, will be only too glad to avail themselves of such an arrangement.

I believe I do not give away any secrets if I tell you that we sell our current to the city for the value of the coal equivalent of our gas. The price which the city pays is, therefore, very small. While the city charges from two to two and a half marks per kw hour, we furnish to the city the kw hour for three tenths of a mark. We make money by this arrangement and the city makes much more money.

Distribution of Tar Recovery From By-Product Coke Oven Gas

Some Interesting Experimental Work on the Recovery of Tar Is Tabulated—Distribution Figures Are Given.

By FREDERICK M. WASHBURN and GEORGE E. MUNS*

AT the by-product coke plant of the Wisconsin Steel Works, located at South Chicago, Ill., an investigation was made into the quantity and composition of the tar removed at various points along the path of the gas, resulting in the data given below.

The plant consists of two batteries, each of 44 Wilputte ovens, together with complete direct type by-product recovery apparatus. The gas is conducted by goose-necks from the top of the oven through a mushroom valve and into the collecting main. At the mushroom valve it meets a spray of flushing liquor, which prevents pitching of the valve seats. The gas is then drawn through the suction mains where it is again sprayed with flushing liquor and conducted to primary coolers, which are of standard indirect type, water tube design. From this point it passes through Root positive exhausters, which force it through the tar extractor and other apparatus for the recovery of by-products.

Fig. 1 shows diagrammatically the flow of gas from the ovens through the gas mains and apparatus, and the points at which condensed or extracted tar is drawn off for subsequent separation and storage. Temperature and pressure conditions are shown by notation at these points.

All tests were run under uniform operating conditions, with temperatures and pressures normal, with an average net coking time of 22 hours 51 minutes, and with a coal mixture of 95 per cent Benham (high volatile) and 5 per cent Pocahontas (low volatile) coal. Average tar and gas yields per ton of dry coal charged were taken over a period of 24 days operating at this coking time, and amounted to 11.39 gallons of tar and 11,365 cu. ft. of gas. All figures in tar gallonage are calculated on a moisture free basis because of the wide variation in moisture content of different tars separated.

The general plan of the test was to actually measure the tar recovered at the different points for a definite period of time, noting the total volume of gas handled during that time, and obtaining a representative sample for analysis of the tar produced. Lack of tank space

made the actual running time of the tests shorter than was expected, but good checks were obtained by repeating. In detail, the procedure was as follows:

Test A—P. & A. Tar Extractors.

The hot drain tank was isolated and the tar separated by the P. & A.'s discharged into this tank. Measurements were made at the start and finish of each run, and gallonage determined from the tank calibration and measurements. The sample for analysis was taken from the seal pot overflow.

Test B—Gas Chamber (After Exhauster).

The gas chamber was emptied at the start. During the run the condensate was drained into tarred barrels at regular intervals, and at the finish of the run. The gallonage was determined from the weight and specific gravity of the tar. The sample for analysis was taken from the barrels.

Test C—Exhauster Drain (Section Side).

The exhauster drains were sealed off in 500-gal, cylindrical tubs, which were measured at start and finish of run, and the gallonage determined by calibration and measurements. The sample for analysis was taken from the tubs.

Test D—Primary Coolers.

The drains from the primary coolers were discharged into the isolated hot drain tank, which was measured at the start and finish of the run. The gallonage was determined by the tank measurements and calibration. The samples for analysis were taken at the siphon pot.

Test E—Suction and Collecting Mains.

This tar occurred in small quantities in comparatively large quantities of liquor, and owing to the difficulty of measurement, the amount of tar separated here was obtained by the difference between the previous tests and the total production. Separate samples for analysis were taken from the suction and collecting mains. In order to secure an uncontaminated sample, an all liquor flush was circulated for four hours before the test and during the test.

*Mr. Washburn is coke plant chemist and Mr. Muns general by-product foreman at the plant of the Wisconsin Steel Works.

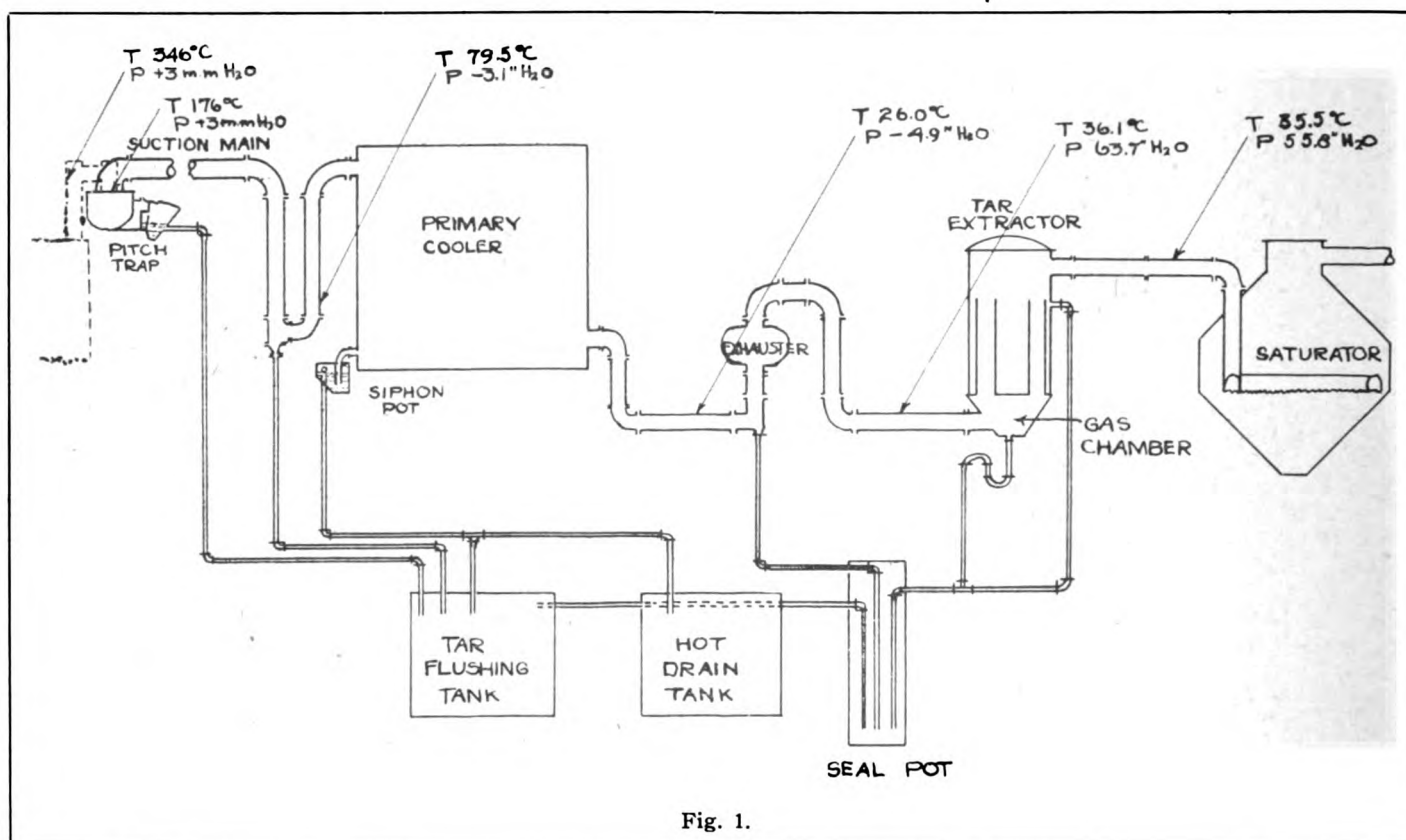


Fig. 1.

Moisture determinations were made on all samples except those from the suction and collecting mains. All samples were dehydrated, and specific gravity, free carbon and distillation determinations made on the dehydrated tars. The specific gravity determinations were made with a Westphal balance with the exception of the samples from the suction and collecting mains, which were too viscous for this method, so a tar specific gravity bottle was used. The distillations were made on a 100 cc. sample in a 200 cc. side neck distillation flask connected to a vertical condenser.

Table I—Distribution of Tar

Test	Location	Duration of Run	Gas Passed M. ft. ³	Gals. Tar Obtained	Gals. Tar per M. ft. ³ of Gas	Percentage of Total Tar Production
A	P. & A. Tar Extractor	325	2451.5	179.03	.0732	7.30
B	Gas Chamber	325	2451.5	49.50	.0202	2.01
C	Exhauster	325	2451.5	433.26	.1767	17.64
D	Primary Cooler	120	867.5	354.96	.4092	40.84
E	Suction Main				.3227	32.21
F	Collecting Main					

Table II—Analysis of Tar

Test	Moisture	Sp. Gr. 15.5°C.	Free Carbon	Under 110° 110°C. 170°	170° 235°	235° 270°	270° Residue	
A	4.45	1.135	4.21	1.5%	6.0	39.5	9.5	37.0
B	.47	1.140	3.45	1.0	3.0	30.0	10.5	50.0
C	6.50	1.121	3.44	1.5	6.5	33.0	10.0	42.0
D	5.00	1.140	3.48	.5	5.0	35.5	11.0	42.0
E	...	1.229	11.94	..	..	2.5	4.0	87.5
F	...	1.202	10.92	..	..	5.0	6.0	82.0

The tar obtained from the exhauster drains (Test C) probably represents separated tar mechanically carried over from the primary coolers, as from Table II it may be seen that Samples C and D are very similar in com-

position. Sample C is a slightly lighter tar than Sample D, which would naturally follow, since Sample D is composed of tar separated in all sections of the primary coolers, while Sample C probably consists mainly of tar from the last or coldest section. From Table I it may be seen that over 90 per cent of the tar present in the gas is removed during its passage through the mains and primary coolers. Two per cent of the remaining tar is removed by passage through the exhauster, leaving only a little over 7 per cent to be removed by the tar extractor. The free carbon and residues on Samples E and F are extremely high due to coal dust mechanically carried over from the ovens. This coal dust is subsequently removed in a pitch trap. The tar from Tests E and F is very heavy and viscous, since they were separated at a high temperature. As the separation temperature is lowered, the tars become lighter and more fluid. Due to the increase in pressure and temperature caused by passage through the exhauster, a heavier tar is separated from the gas chamber (Test B). Up to this point the separation of tar has been governed mainly by temperature and pressure conditions, but in the P. & A. tar extractor, the temperature and pressure cease to play such an important part, for the mechanical action of the impingement of the gas on a surface causes the separation. The tar separated from the tar extractor (Test A) represents practically the last traces of tar in the gas, and is the tar having the greatest percentage of oils and least pitch residue of any of the tars tested.

STEEL COMPANIES CONSOLIDATE

Arrangements have been made for the consolidation of the Electric Alloy Steel Company of Youngstown and The Atlas Crucible Steel Company of Dunkirk, N. Y. Approval of the respective boards of directors is all that is necessary to close the deal.

Use and Abuse of Powdered Fuel for Stationary Boilers

Any Great Advance in Combined Boiler and Furnace Efficiency Will Depend Largely Upon the Full Utilization of Radiant Heat.

By JOHN E. MUHLFELD*

THE first successful use of powdered fuel was in cement kilns. As the requirements in efficiency and economy for that purpose were not such as to necessitate complete combustion in a short distance, nor any particular disposal of the non-combustible due to the latter being reclaimed with the product, and as the price of coal at that time was relatively cheap, these factors were of no great import.

When the burning of powdered fuel was introduced in stationary boiler furnaces located in cities and towns, entirely different and more difficult conditions were encountered, and numerous troubles in pulverization, storage, conveying and feeding, as well as due to the inability to secure quick and complete combustion in short travel and small space, and to overcome the difficulties resulting from the unconsumed combustible and the ash accumulating in the boiler and furnaces in the form of slag, honeycomb or fine dust, as well as being discharged from the stack, became immediately apparent. As a result, during the past ten years a great deal of information has been presented before various engineering societies and published in technical and trade journals and papers as to how these difficulties could be overcome, but inasmuch as a large amount of this information has been compiled by people who have not been directly responsible for devising means, methods and processes for the development, installation and operation of powdered coal, the broadcasting of a lot of this misleading, unfounded, and purely theoretical information has resulted in many false impressions and in numerous installations of powdered fuel burning equipment with attendant high initial investment and operating costs, and performance disappointments, which could have been avoided by competent engineering analyses and supervision.

Hazard.

Danger from the use of powdered fuel, more particularly during the early stages of its development, was largely due to the drying and pulverization equipment and processes used, the mixing of the powdered fuel and air in a combustible state for conveyance and distribution for long distances prior to storage or feeding to the furnace, and to the lack of practical knowledge, instructions and experience.

A number of systems are still in use and being installed which involve a certain element of danger when there is a failure to observe the proper instructions, but the more recent developments, whereby the necessity for direct or indirect heat drying prior to powdering is now made unnecessary, and the powdered fuel can be conveyed direct from the pulverizing equipment to the furnace without intermediate storage or distribution, practically eliminate the liability for spontaneous combustion.

*Consulting Engineer, New York City.

fires or explosions that may be caused by negligence, and reduce the hazard below that which obtains with the use of fuel oil or gas.

Preparation and Storage.

The investment, upkeep and operating cost for the preparation and storage of fuel in powdered form has been the greatest single factor in retarding its more extended use, particularly in plants using less than an average of 80 tons of fuel daily where the greater capacity, efficiency and economy obtainable do not justify the increased fixed charge. This has been due principally to the fact that the majority of the pulverizing mills, which are in use and being marketed today, were originally designed for the powdering of cement clinker, ores and paints and not adapted to fuel. Pulverizing equipment of this kind, wherein the sizing of the product is dependent upon its passage through screens, was largely responsible for the use of direct and indirect heat fuel dryers and for the early claims that fuel for pulverization should be dried to a moisture content of not less than one per cent. While the development of the air-separation types of pulverizers brought about a considerable improvement in this regard, they did not, particularly for the reason of the first cost and the cost for operation, greatly relieve the situation, and it has remained for a self-contained unit system of pulverization, which is now being developed along efficient and practical lines, to enable the elimination of large and expensive buildings, storage bins elevating and conveying equipment, dryers, pulverizers, and all other intermediate and accessory machinery.

Another retarding factor and which resulted from the use of powdered coal in cement kilns, and experimentally in steam locomotives, has been the general impression that the fuel must be of such fineness that at least 95 per cent will pass through a 100-mesh, and at least 85 per cent through a 200-mesh screen. The cost to produce this degree of pulverization by direct or indirect heat drying and milling is substantially higher than the cost for combination air-drying and milling to a fineness of about 90 per cent through 100-mesh, and 70 to 75 per cent through 200-mesh, which it has been found produces entirely satisfactory results with bituminous coals and lignites.

Distribution.

The generally designed preparation plant consisting of storage, drying, pulverizing, elevating, conveying and other intermediate apparatus requires a considerable amount of equipment, power and maintenance for the handling and distribution of the raw, dried and powdered fuel. Where systems which combine and distribute combustible mixtures of powdered coal and air are installed,

the power requirement for such distribution and circulation is also a large additional item of expense.

By substituting for such installations a self-contained unit system of air-drying, pulverizing and distribution, a much less expensive and complicated and a more efficient and economical operating arrangement can be provided.

Feeders and Burners.

Much time and money has been and is still being expended in devising feeders and burners for introducing powdered fuel into stationary boiler furnaces, whereas any simple device which will continuously and uniformly introduce a predetermined supply of powdered fuel and air mixture into the furnace will successfully meet all requirements.

Furnaces and Boiler Baffles.

Various installations and tests made during the past ten years in the burning of powdered anthracite and bituminous coal and lignite, on different types of boilers in combination with various designs of furnaces and baffles, have erroneously led to the general opinion that only vertically baffled boilers are suitable for the burning of powdered fuels in suspension. The reason for this may be attributed to the greater average depth of the combustion space found in combination with vertically baffled boilers, as well as the permissible use of a vertically and downwardly injected fuel stream into a preliminary combustion chamber leading to the furnace proper, and which arrangement provides for a relatively long flameway and time element prior to the absorption of the heat combustion. Vertically baffled boilers, with the usual means and methods in vogue, have also reduced the liability for the accumulation of honeycomb and ash dust in the boiler tube passes.

Early experiments on horizontally and vertically baffled boilers of different types indicated that with suitable furnace and soot blower equipment the evaporation results from the horizontally baffled boilers were equivalent if not greater than for vertically baffled boilers, the reason for this being a more favorable arrangement of heat absorbing and radiating walls of the furnace for the purpose of flame and radiant heat propagation.

A stationary boiler installation is now being made in the Central West where the horizontal system of baffling, in combination with improved fuel preparing, burning and furnace equipment, is being introduced for the use of powdered fuel, and the testing out of this equipment will soon develop as to the economy in first cost and for upkeep and operation, practicability and general utility of this system as compared with the other most successful systems now in use.

Combustion.

Almost any practical means and methods may be employed to bring about the combustion of powdered fuel, but it remains for a scientifically correct combination of fuel, preparation, fuel and air mixture, feeding, furnace, induction air, draft, boiler baffling, soot blowers, and gas areas to produce an oxidizing atmosphere in the furnace at all times, in order to produce efficient "ferric oxide" instead of deficient "ferrous sulphide" chemical reaction or combustion results. This process of chemical reaction having been completed, there must then be such combination of air and flame-way travel as to insure proper CO₂, heat and ash control if satisfactory results are to be accomplished. Frequently one or more of these essential factors are missing due to either the equipment or the methods of operation.

Brickwork Wear and Tear.

The destructive agencies of temperature, slag, abrasion, corrosion and eutectic action, all of which must be resisted by the refractory materials used in the furnace walls and baffles, have, in many instances, been a serious obstacle to a continuation of the use of powdered coal. Too much importance cannot be placed upon the kind and installation of refractory, arrangement of the heat absorbing and radiating walls of the furnaces and baffles, calculation and adjustment of the gas areas through the boiler, and especially to the adjustment of the flame-ways in a manner to avoid heat concentration and scouring action on any of the refractory walls.

The ordinary feeding and burning equipment is such that the control of the flameway and the combustion is dependent largely upon the velocity with which the fuel mixture enters the furnace, and on the regulation of the stack draft and air. Such arrangements cannot produce the most satisfactory combustion, refractory and evaporation results and the provision of means for easily, quickly and closely regulating the direction and volume of the flameways in the furnace is a most essential but greatly overlooked adjunct.

Ash.

Pulverization of fuel necessarily combines with it the non-combustible, the fine particles of which are either deposited in the furnace proper, on the boiler surfaces and baffles, or otherwise pass through the stack to the atmosphere. Those particles which are deposited on the boiler surfaces and baffles can, with proper mechanical facilities, be readily blown off, and those collecting in the furnace may be removed in the usual way, unless, due to unsuitable burning or furnace equipment, they are allowed to fuse into slag.

Great stress is laid by many power plant and stoker builders and operators on the percentage of the ash which finds its way to the atmosphere through the stack, but from observations made during the past five years, of the stack of the Oneida Street Power Plant of the Milwaukee Electric Railway & Light Company, Milwaukee, Wis., when carrying the load on each the powdered fuel and the stoker fired boilers, sufficient practical evidence is available to show that the impalpable ash particles emitted from the former are decidedly less objectionable than the smoke and cinders emitted from the latter. In fact, as yet no evidence has been found of the ash which comes from the powdered fuel equipped boilers. It should be remembered, however, that the system employed for the burning of powdered fuel has much to do with the results to be obtained in this direction, and that several boiler plants are now, or have been operated with powdered fuel systems where not only the ash, but also the unconsumed fuel particles emitted from the stacks have been a serious menace. Even in such cases there has not been the objection such as can be raised to the smoke and cinders carried out of the stack by stationary or traveling grate, or retort, stoker fired boilers, especially when operated under peak loads.

Slag.

With powdered fuel burning furnaces, slag is the result of the fine molten or dry particles of ash deposited on the furnace floor being retained in a high temperature location, with resulting fusing into a conglomerate mass, and these collections of slag have been the cause for considerable experimentation, annoyance and expense. In some cases, extreme measures have been resorted to, such as the installation of undesirable so-called

water screens, supplementary to the boiler proper, located just above the furnace floors, for the purpose of introducing a cooling effect at that point to prevent slagging, but these, through the interposition of heat-absorbing and combustion cooling surfaces, invariably reduce the furnace efficiency otherwise obtainable. Also air-cooled furnace floors, molten slag hoppers, steam sprays, and like devices have in some cases been resorted to, but without satisfactory results.

A proper analysis of slag troubles will determine that suitable furnace design, production of "ferric oxide" rather than "ferrous sulphide" combustion, and regulation of CO_2 is all that is required to eliminate troublesome slag conditions.

Pre-Heating of Combustion Area.

With the usual powdered fuel installations the pre-heating of air, for the purpose of advancing combustion, unless it can be accomplished by means of waste heat in combination with simplified means and methods, is not productive of any considerable net economy. However, with more adaptable furnace and combination pressure and induction combustion air systems a simplified arrangement of furnace design and construction can be devised whereby pre-heated air may be more economically utilized.

Superheat.

The regulation of superheat temperatures, more particularly where the superheaters are of the radiant heat type, or otherwise located in the furnace brickwork instead of the boiler gas passages, is a factor not to be overlooked, for the reason that lack of superheat temperature is bound to be reflected in machinery, lubrication, efficiency and upkeep troubles, and with the use of powdered fuel it is most important that an automatic and simple device for such regulation be provided.

Conclusions.

Central power station, industrial boiler plant, and marine and locomotive boiler operations have long since established the desirability, efficiency and economy of using oil or gas for steam generation, but the gradual

depletion of such fuels for these purposes, the increasing cost for all gaseous, liquid and solid combustibles, and the accentuated public and industrial interest in the necessity for greater conservation and utilization of fuel by-products or deposits which have not heretofore been workable to commercial advantage, will now make necessary the use of the practically inexhaustible stores of inferior bituminous and anthracite fuels and lignites in the most effective manner, and which, in powdered form, enables them to be burned in suspension, the same as natural gas and fuel oil.

Any great advance in combined boiler and furnace efficiency will depend largely upon the full utilization of radiant heat. When solid fuels are burned on grates or in retorts the heat given out is radiant only until the first evaporation surfaces are reached, whereas with powdered fuel burned in suspension, the solid and gaseous products of combustion, as well as the increased refractory surfaces, project radiant heat direct to a relatively large proportion of the heating surfaces and this enables an increase of from 20 to 30 per cent in the otherwise obtainable thermal efficiency of those boiler portions which are directly affected. In fact, the use of powdered fuel, as compared with stoker firing, has shown higher overload and average working boiler capacities, greater efficiencies at the higher ratings, lower banking and stand-by period fuel consumption, reduction of non-productive labor for ash-handling and boiler and furnace upkeep, elimination of the smoke and cinder nuisances, ability to use available supplies of cheap, low-grade fuels, and practicability to burn gaseous, liquid or solid fuels in combination or independently.

While the necessity for the special preparation of the powdered fuel has been a retarding factor in its more extended use, the past ten years' experimentation has developed that separate and costly fuel preparing, storage and distributing plants are unnecessary adjuncts for the use of powdered fuel, as the equipment for the latter can now be made a self-contained part of the boiler plant and will require no more under-cover space than for the installation of modern grate or retort stokers.

Waste Heat Boilers in Steel Plants

All Modern Waste Heat Boilers, Applied to Such Operations as Formerly Depended on Natural Draft, Must Be Equipped With Induced Draft Fans.

By J. C. HAYES*

THE fact that there has been a remarkable revival of interest in waste heat boiler equipment in the past few months is a logical development in view of the sequence of events as affecting waste heat boiler practice in this country.

In a paper read before the American Iron & Steel Institute in 1915, Mr. C. J. Bacon—who was steam engineer at the South Chicago plant of the Illinois Steel Company where most of the experimental work was done—gave the results of the preliminary work, together with an outline of the possibilities of further savings by taking advantage of the knowledge gained in the development work up to that time.

*Plant Engineer, Freyn, Brassert & Company, Chicago, Ill.

In a discussion of this paper Dr. D. S. Jacobus of the Babcock & Wilcox Company stated that the conditions indicated in the early stages of Mr. Bacon's work resulted in the Babcock & Wilcox Company making a careful study in order to determine the best means of applying boilers to this class of service, and that the investigations resulted in a radical change in their waste heat practice.

It may thus be seen that the waste heat boiler as it is known today was only fairly well established as an essential to economical open hearth practice, when the war demand for steel, especially plates, forced the consideration of tonnage with apparent disregard for the cost of production.

Of one thing we may be sure—the cost of fuel will always be a major item in the cost of any product requiring heat for its production, and the waste heat boiler as an institution is here to stay, especially as it has been shown that any process in which steam is used and in which the equivalent of 20,000 pounds of gas an hour at a temperature of 900 deg. F. or more is now wasted may look forward to the use of a waste heat boiler as a means of reducing manufacturing costs.

Practically all the recently built open hearth furnaces, as well as many other types of furnaces, either have waste heat boilers as part of the original installation or have space provided in the design for future boilers.

A boiler designed for the recovery of waste heat from comparatively low temperature gases must be one in which the gases pass across the heating surface at relatively high velocity when compared with the ordinary direct fired boiler.

In a boiler using direct fuel, as much as 65 per cent of the heat may be transferred by radiation, or in other words, may be absorbed directly by the tubes from the incandescent fuel bed, arches and furnace walls. It is generally conceded that heat thus absorbed varies directly as the fourth power of the temperature difference between the tubes and the radiating surface. In the waste heat boiler, the heat thus available is less than one-tenth of that available in a direct fired boiler because of the absence of intensely heated surface, and the further fact that much less of the heating surface is exposed to the action of the radiant heat from the incoming gas passages.

The success of the waste heat boiler is therefore dependent almost entirely on the heat extracted from the gas by convection or direct contact of the gas with the heating surface.

In order to accomplish the maximum contact of hot gas and tube surface, there must be a positive scrubbing or tumbling action of the gas which is accomplished by the high velocity at which it is passed across or through the tubes, thereby preventing the natural tendency of the gas to form an insulating film of cool gas close to the heating surface and allow a hotter center, or core, to pass on without giving up its heat.

It was the demonstration of the effect of high velocity on heat transfer that brought about the radical change in waste heat boiler practice. The failure to recognize, or the inability to comply with the high velocity requirements in waste heat practice, was undoubtedly the cause of many failures in the early attempts to recover waste heat from industrial furnace gases, especially where the temperature of the waste gas was below 1800 deg. F. Many forges and melting furnaces were equipped with various types of waste heat boilers and considerable recovery of heat in the form of steam was noted in such installations as approximated straight coal fired conditions; that is, where waste gases were at a temperature of over 1800 deg. F. and the natural draft was sufficient to pull the gas through the boiler and still provide enough draft for the heating furnace.

Such boilers were generally one-pass fire or water tube boilers set vertically over the furnace and exhausted the gas directly to superimposed stacks. The waste gases from some of these furnaces were as high as 2400 deg. F. and the recovery was good on account of the relatively large amount of heat absorbed by direct radiation.

All modern waste heat boilers, applied to such operations as formerly depended on natural draft, must be equipped with induced draft fans. Ordinarily, not over

8 per cent of the steam generated by a boiler is required for driving the fan, and in cases where the exhaust steam can be used to heat feed water, the net loss chargeable to the operation is less than two per cent of the total evaporation.

A 75-ton open hearth furnace in which 70,000 lbs. of waste gas is available at a temperature of 1200 deg. F. will yield a net recovery of 354 Bo. hp. per hour in steam at 160 lbs. per sq. in. pressure and 100 deg. superheat when equipped with a standard superheater and a two-pass boiler having 5,700 sq. ft. of heating surface. Under these conditions the gas will be reduced to a final temperature of 520 deg. F. and the draft loss through the boiler proper will be 1.8 inches head of water. The fan for this particular installation will have to handle the gas at a differential of 2.5 inches head of water to make up for frictional losses in the valves, flues and superheater.

In certain cases it may be profitable to reduce the final gas temperature much lower than 520 deg. F. The test data now available for calculating the performance of waste heat boilers is such that the amount of heat recoverable under any given set of conditions may be accurately predicted, and the advisability of obtaining final temperatures below, say, 520 deg. F. is merely a matter of capitalizing the extra investment required for extending the heating surface and making allowance for the added power required for driving the fan.

There are a number of fire tube boilers now in waste heat service in which final gas temperatures average less than 400 deg. F. These are three-pass boilers in which the last pass serves as an economizer element. The size of tubes and amount of heating surface in a boiler for any given weight of gas is ordinarily based on reducing the temperature of the gas to a minimum of 450 deg. F. and a maximum of 550 deg. F. Final temperatures outside this range are not economical except in such cases as the investment in an economizer element is considered.

Any type of water tube boiler that is satisfactory for straight fire service may be adapted to waste heat service by arranging the baffles so as to increase the gas velocity, but it has been shown that those types in which the gas passes at right angles to the center line of the tubes, or approximately so, will give better heat transfer than those in which the flow of gas is parallel to the center line of the tubes. While this is also true to some extent in direct fired boilers, the particular advantage in waste heat practice is on account of the relatively large portion of the heat that is absorbed by convection in the waste heat boiler.

On account of the higher gas pressure differences between passes, the baffling on water tube boilers must be particularly tight. Improvements in the way of double walls, special shapes and monolithic baffles have recently been developed for this service.

Infiltration of air through brick walls is a greater source of loss in waste heat practice than in direct firing. For this reason particular attention must be paid to keeping the settings free from leaks. A number of water tube boilers have been installed with the settings entirely enclosed in steel plate.

In fire tube boilers air infiltration is practically nil, therefore the gas velocities may be greater and the consequent high differential between incoming and outgoing gas may be maintained over an extended steaming campaign with no danger of overloading the fan or losing heat on account of defective walls or baffles.

WITH THE EQUIPMENT MANUFACTURERS

New Operating Head Revolutionizes Operation of Soot Cleaners

A new device which, it is said, will revolutionize the operation of mechanical soot cleaners, has just been announced by the Vulcan Soot Cleaner Company of Du-Bois, Pa., manufacturers of Vulcan soot cleaners. It is claimed that the device is the newest and most advanced principle in soot cleaner operation, and is destined to insure a more thorough removal of soot than has been possible hitherto in many plants as a result of careless or too hasty use of the soot cleaning apparatus.

The device announced by the Vulcan Company is the new Vulcan ratchet operating head, illustrated in Fig. 1, the basic principle of which is automatically to limit the sweep of the soot cleaning element, to force the operator to operate the element in a step-by-step movement, and hence to insure that the steam jets have an opportunity to sweep over and thoroughly clean every part of the tube surfaces.

For many years a small percentage of soot cleaner owners have complained that soot cleaners did not thoroughly remove the soot accumulations. Investigation disclosed, in a majority of these cases, that the cleaning elements either were being rotated too fast or rotated by careless workmen through only a fraction of the full

and only then, a pull on the chain causes the element to rotate another space. Between the lulls in operating the new head, the steam jets have an opportunity to concentrate upon a definite section of the tube surface for a length of time sufficient to insure a thorough removal of the soot. When the complete arc of rotation has been attained in one direction, which is limited by "stops" especially set for that purpose, the mechanism automatically reverses itself and the cleaning element moves back in the same manner through the same arc. Any soot that may have redeposited after the first rotation is completely removed on the backward travel.

In designing this ratchet operating head, the Vulcan engineers kept constantly before them the fundamental purpose of every soot cleaning apparatus, namely, to remove the soot thoroughly, and built their operating head with this purpose only in mind, regardless of the competency of the individual doing the actual work of handling the equipment. The net result is a device that takes the control of cleaning entirely out of the hands of the operator and places it solely in the ratchet operating head.

The Vulcan ratchet operating head possesses five features of paramount importance to the power plant engineer. These are:

- (1) It absolutely prevents the man operating it from neglecting any part of the complete sweep of the cleaning element.
- (2) It substitutes a uniform rate of speed of rotation, in a step-by-step movement, controlled almost entirely by the head itself, in place of the old irregular, uncertain rate controlled by the whim of the operator and his desire to get through with the job as quickly as possible.
- (3) It assures a considerable saving in quantity of steam used, because the operator knows that he has to make the sweep only once in each direction and can stop when that has been completed.
- (4) It provides the operator with a clearly defined task, instead of a vague and indefinite one.
- (5) Above all, it entirely eliminates wrong methods of soot cleaning, and is an assurance of more satisfactory and thorough cleaning results.

The new head, as may be seen from the illustration, is remarkably simple and strong. Its action is positive and sure. There is not a part to slip out of place and thereby throw the whole device out of action. The chain is securely riveted to the ends of the ratchet frame and no amount of pulling or jerking will tear it loose.

This new Vulcan ratchet head is operated independently of the valve. Therefore, should the element operating mechanism accidentally fail during operation the whole cleaner system is not put out of commission while repairs are being made.

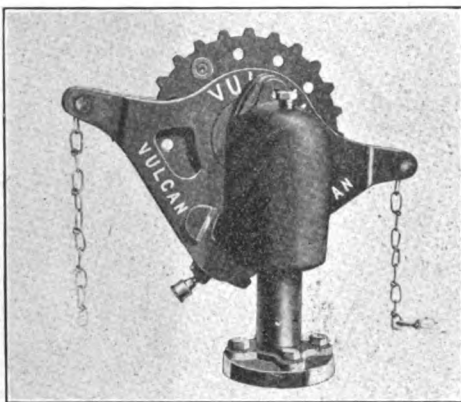


Fig. 1.

permissible sweep of the elements. As a result, the cleaner was prevented from doing its proper work, through failure to give the steam jets time enough to thoroughly clean the tube surfaces.

To correct this difficulty, to make soot cleaner operation more mechanical and less dependent upon the efficiency of the human factor in the boiler room, the new Vulcan ratchet operating head was designed and is now being placed upon the market.

The new head is so constructed that when the operator pulls the chain the element is rotated only a short distance and can be turned no farther until the ratchet frame has been returned to its original position. Then,

New Rolls For Steel Mills

The advance in the art of hot working iron and steel by means of rolls has been given an added impetus by the introduction of the **molybdenum** steel rolls of the Wheeling Mold and Foundry Company. The use of molybdenum steels during the past few years in the automobile industry had proved the desirable qualities of strength and resistance to shock. Experience in die and other hot working steels had developed another desirable quality in these steels; namely, resistance to the effect of hot work to a greater degree

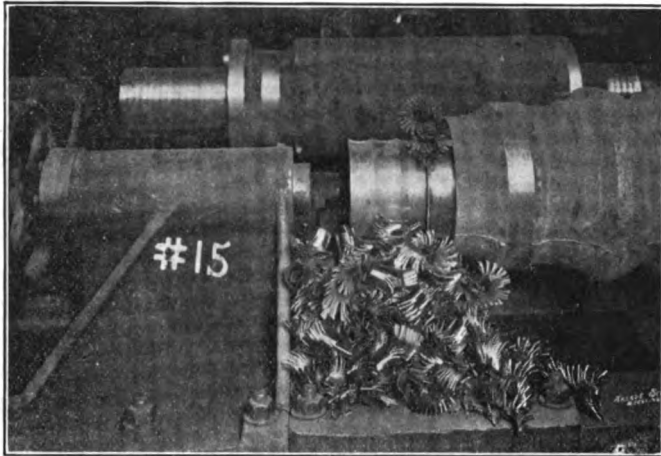


Fig. 1—This cut shows a molybdenum roll in the lathe and the turnings cut from it. It is particularly interesting to note that these turnings formed in highly blued, tough, strong springy spirals, indicating a similar quality in the steel, far superior to any that has been observed heretofore. The very noteworthy fact was encountered that, although these rolls developed a scleroscope hardness of 50 to a depth of about six inches, they still possessed the toughness of low carbon steel.

than in other commercial steels. Familiarity with these qualities led the Wheeling Mold and Foundry Company, with the cooperation of the Molybdenum Corporation of America, to experiment with similar steels for rolls.

Experimental work was undertaken about the middle of 1920. Small electric furnace heats were made, cast and subjected to many different experimental heat treatments. The results of this research showed enough merit in the molybdenum steels to justify the solicitation of an order for a set of molybdenum rolls for practical mill test. The order was secured and the rolls made in June, 1921. Shop tests on these rolls, such as physical property tests and machining tests, etc., confirmed their opinion of the desirability of molybdenum rolls and their desire to push the matter further. Photographic evidence of the machining test is shown herewith.

Since these first rolls were made, the Company has developed the heat treatment processes to such an extent that with a slight difference in composition and heat treatment, they can produce rolls ideally adapted to any purpose from the strongest roughing roll to the hardest finishing roll. In each case the rolls are exceptionally tough and able to withstand an enormous

amount of abuse and can be treated at the same time to show a hardness suitable for any mill condition. No other alloy steel is useful for so many places in rolling mills.

The two main characteristics desirable in rolls are resistance to wear, and strength. Resistance to wear is the result of a combination of hardness and toughness plus heat resisting properties. Molybdenum rolls possess these characteristics to a marked degree, to an extent, in fact, which should produce a two hundred per cent increased service over that of the carbon steel roll practice. A greatly increased number of dressings before the rolls are reduced to their smallest permissible diameter is possible from the known fact that these heat treated molybdenum rolls reduce side wear to a minimum and, therefore, necessitate small reductions in diameter to bring back the shape of the groove. When used as roughing rolls, the increased hardness and consequent resistance to wear, is not at the expense of proper mill practice. Experience shows the rolls to have a good bite and slippage is not encountered as is the case with the high carbon alloy steel rolls now in common use. In cases where ragging is necessary, the sharp corners hold up in a most satisfactory manner. When used in finishing rolls, the passes retain the shape of the section and produce a

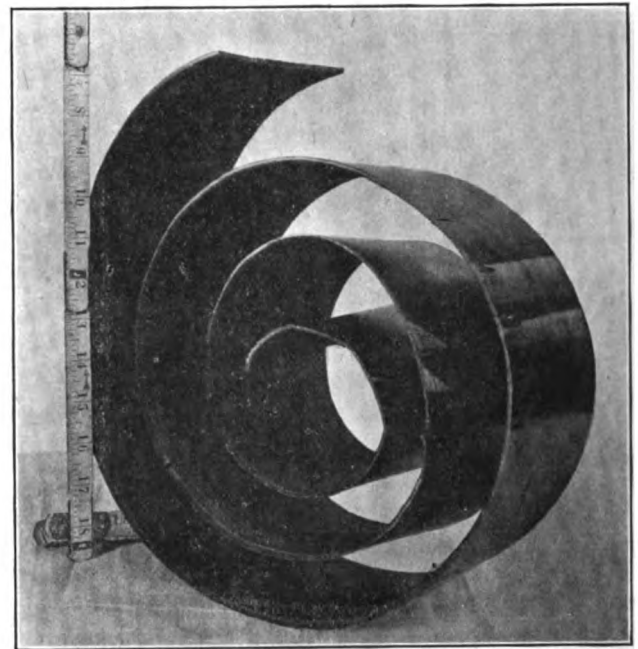


Fig. 2—This cut shows an individual turning which speaks for itself.

very smooth finish due to the continued absence of fire cracks, pits and other surface irregularities. In current practice an example can be cited where these molybdenum rolls have been used for very severe service in a small roughing stand. The excessive breakage was entirely eliminated and two hundred per cent increase in tonnage was secured per dressing with fifty

per cent less reduction in diameter.

It is believed that the use of molybdenum steel rolls will permit of a great increase in the size of the entering billet, possibly as much as thirty per cent, as well as to permit of an increased roll length in proportion to the diameter. In addition to the resistance to wear and the strength just mentioned, the molybdenum steel rolls possess great resistance to shocks. This characteristic will be appreciated in that it will assist in offsetting the occasional accidents that occur even in the best mill practice.

It must not be thought that these results have been obtained in only a few cases. Many rolls have been made, varying in size from five hundred pounds to forty-five thousand pounds, with consistently satisfactory results in the foundry and steel plants. These

rolls are proving themselves in service and daily new reports of satisfactory results are being received. In no case has there been a failure.

It would be well to state that molybdenum sand rolls and molybdenum chilled rolls are in service and to date are showing up very satisfactorily. In one case, molybdenum sand rolls have been thoroughly tested in a large billet mill and results obtained justified the adoption permanently of this type of roll. Somewhat the same qualities are brought out in the iron as in the steel rolls and equally excellent results are anticipated.

The Wheeling Mold and Foundry Company believe that the development of molybdenum rolls is the greatest stride forward in the roll industry in the last quarter century.

Centralized Control

There have been many examples to show the advantages and economic need of intelligent centralized control—in the hands of one power in which is concentrated the information and judgment best obtainable under the conditions.

Without such single directing force the Allies in the last year of the World War would scarcely have been able to defeat the Central Powers under the well directed leadership of Germany; and without such centralized control the Allies now stand wavering before the diplomatic attacks which beset the peace and bid fair to shatter the Treaty of Versailles.

A most interesting exposition of the possibilities of centralized control, indeed revolutionary in effect, is that of the air brake. Before its era a signal was given by the whistle on the locomotive and half a dozen men sprang to the hand wheels of the individual cars—sometimes they lagged a little or set the brakes too hard. Contrast this with the absolutely perfect control now in the hands of the engine driver. Is there need to ask what would become of our modern railway service without the air brake and its control valve in the cab of the locomotive?

Less absolutely essential, perhaps, but still of vital importance in the conservation of fuel, centralized control of combustion in our large power houses is fighting for recognition against the old time-honored methods which seem to have such a strong hold upon the minds of engineers.

From time to time important steps have been taken, one of the most noteworthy being the introduction of so-called "time-firing" where coal is used for fuel and it is fired by hand. This system, so far as the writer knows, was first introduced by Commander W. W. White, U. S. N., about 20 years ago in connection with "trial trips" of new naval vessels. These tests always included steaming for a considerable period at maximum power and speed, and it was absolutely essential that full steam pressure should be maintained at such times. Commander White had noted, under the old system, that some of the firemen kept good fires while others fired at infrequent periods and shoveled the coal into the furnaces to mountainous heights. So he worked out a plan

by which, at a given signal, each fireman had to get up and "do something"—he went further and told him what to do. Each fire door was numbered, and the scheme so worked out that "firing," "raking" or "slicing" should come at a certain specified moment for a particular door. He also specified closely the number of shovels of coal which should be fired at each interval. This idea proved very effective and for many years, and, in fact, until the introduction of oil fuel, not a battleship or cruiser went out for her trials without a "time firing" system on board, and many ingenious modifications in the signals were worked out. All of them, however, were based on the principle that the control of the signals, i. e., the time interval should be in the hands of one man who became solely responsible for the keeping up of the steam supply.

Time firing was found to be of such value in naval work that the signaling device was specified in the contract and made part of the standard equipment. It was also used successfully in large merchant vessels.

It is obvious that this time firing system, i. e., centralized control of hand firing of coal, had practically no bearing on labor saving. The same number of firemen were required as before. It did have the effect of producing plenty of steam and it did save fuel, but it cost the government or owner just as much for labor.

But if centralized control, in addition to its other advantages, results in marked saving in labor it becomes at once a factor in power development which cannot be ignored. It is in the use of oil as fuel that the full opportunity in this direction presents itself. Here the oil spray takes the place of the "coal heaver," and, if means may be developed for controlling the oil spray at one central point, then it is evident that the only labor required is that of supervising the sprayers or atomizers to make sure that each is operating properly and does not require cleaning or repair.

The great saving in labor which results merely from the use of oil alone has probably obscured the fact that additional labor saving is possible and that there are other economic advantages brought about by the introduction of centralized control.

Let us consider for a moment the method of operat-

ing an oil burning installation. If steam atomizers are used one fireman can look after 20 or 30 burners. He gives his attention to these individually, adjusts the oil valves and the steam spray and regulates the dampers to give the proper amount of air supply, and, as the load fluctuates, he makes the necessary changes to suit the conditions. The only trouble is that after a while he finds this work rather arduous and particularly when the load fluctuates rapidly he finds he cannot make the adjustments quickly enough. All the burners require changing at the same time, and he cannot get around fast enough to prevent smoking or excess air from entering the furnaces. Then he gets careless and gives up trying to have everything O.K. at all times, and he finds that, by giving all the burners an excess of steam and all the furnaces an excess of air, he can confine his labors to regulating the oil only. By this means he easily keeps the steam pressure on the plant where it should be, but the waste of steam through the burners and waste of heat up the chimney carries away thousands of good dollars that never come back.

If, on the other hand, mechanical atomizers are used, the waste of steam used for atomizing is at once prevented for the simple reason that none is used; regulation of this loss is taken out of the fireman's hands. But the ordinary type of mechanical atomizer is not sufficiently flexible to meet the requirements of a fluctuating load, so the burners have to be taken out and tips of various sizes substituted; or, what more frequently happens, some of the burners are extinguished and again ignited to meet the changing conditions and this means that the burners usually have to be disconnected and withdrawn from the furnace to prevent carbonizing when not in service. This requires more firemen.

This defect, however, in the mechanical burner has been met by the recent development of the Peabody-Fisher wide range mechanical atomizer which has a greatly increased range in capacity and is so arranged that any number of burners may be controlled simultaneously by the operation of a single valve on the by-pass oil return line.

With this burner centralized control becomes a simple problem.

LETTERS TO THE EDITOR

Angola, Indiana,
May 11, 1922.

The Blast Furnace and Steel Plant,
Pittsburgh, Pennsylvania,

Dear Sirs: I just received some news from Australia concerning Mr. J. W. Brophy that will interest a large number of your readers who are interested in the outcome of the proposed Queensland State Iron and Steel Works. Mr. Brophy was appointed general manager and erecting engineer of this proposition a couple of years ago; while he was chief mechanical engineer at the Broken Hill Proprietary Steel Works at Newcastle, N. S. W., Australia. Previous to holding this position he was chief mechanical engineer for the Tata Iron and Steel Company, Sakchi, Bengal, India. Mr. Brophy's early training was received in the Pittsburgh district where he still has many friends who will be glad to hear of his success in Australia. I shall give you an exact copy on it from "Truth" a well known Australian newspaper:

"Mr. J. W. Brophy, who has been appointed gen-

eral superintendent of the Queensland State coal mines, is a typical product of American hustle. When an ambitious Labor Government saw the rapid advancement of Queensland through a bold iron and steel works program they found a man of enthusiasm for the job, and Mr. Brophy was the man. But the Government had not calculated on the financial overloads refusing to supply the sinews for the enterprise, and the man from "Amerka" who had been itching to show how they "guess" and "calculate" on such small jobs, was not utilized. The Government recognized that a good man standing by waiting orders is worth paying for standing by alone while the possibilities remain of the orders being eventually delivered. And that is why the Yank dynamo is being allowed to throb among the black diamonds. As the Minister of Mines aptly mentioned concerning the retaining appointment "fuel is fore-runner of iron and steel" and Mr. Brophy is its prophet."

Very truly yours,

BYRON J. BROPHY,
318 South Superior Street,
Angola, Indiana.

15th May, 1922.

Blast Furnace & Steel Plant,
Thaw Building,
Pittsburgh, Pa.

Attention Editorial Department.

Gentlemen: We have been interested by the article appearing on page 289 of your May issue, entitled "The Field of the Large Boiler" by Mr. J. B. Crane.

In the fifth paragraph, the author states:

"If two to four boilers are considered sufficient to supply steam for a 5,000 or 10,000 kw turbine, it should not require more than this number of boilers for a 20,000 or 40,000 kw turbine, and when it is realized how much less apparatus there is to get out of order with a boiler and its auxiliaries than with a turbine and its accompanying apparatus, there must be something wrong with boiler designers if they fail to deliver the goods."

Certainly Mr. Crane is right in this statement, and we invite your attention to the installation at the Lakeside Plant of the Milwaukee Electric Railway and Light Company. Here, there are installed eight 1,306 horsepower Edge Moor Water Tube Boilers. These boilers are operated normally at 250 per cent of their rated capacity and at this output three boilers are sufficient to operate one 20,000 kw turbine, of which there are two in the plant. Two boilers are thus reserved as standbys and for future power requirements.

In a series of fifteen tests, the average efficiency of these boilers with their superheaters and economizers, proved to be 87.3 per cent. An efficiency of 85.6 per cent has been obtained from the boilers alone.

The above information is so apropos to Mr. Crane's article that we believe you may be interested in it.

Very truly yours,

C. R. LONG,
McLain-Simpers Organization.

NEWS OF THE PLANTS

The Sizer Steel Corporation, Buffalo, N. Y., manufacturer of ingots, forged and rolled billets, steel bars, etc., has disposed of a bond issue of \$1,250,000, the proceeds to be used for general extensions and additions in working capital. The company has recently acquired the plant of the Hammond Steel Company, Syracuse, N. Y., and will use a portion of the fund for this purchase. The rolling mills and other departments of the Hammond works, including 1-inch and 10-inch bar mills, will be placed in service at an early date. The property will be operated under the name of the purchasing company, and the Buffalo plant will maintain production as heretofore. C. B. Porter is president.

The Cleveland Cold Drawn Steel Company, 503 Leader-News Bldg., Cleveland, Ohio, has acquired property in the South Buffalo district, Buffalo, N. Y., as a site for the construction of a new plant. Preliminary plans are under way for the erection of a main one-story building and adjoining structures, estimated to cost in excess of \$500,000, including machinery and operating equipment. C. H. Hopkins is secretary and treasurer.

Witherbee, Sherman & Company, 2 Rector Street, New York, N. Y., producer of iron ore, pig iron, etc., with blast furnace at Port Henry, N. Y., has preliminary plans under way for the construction of a new plant unit in the vicinity of the present works. The new blast furnace will have an initial output of 500 tons of pig iron per day, increasing the capacity of the plant to 150,000 tons of pig iron per annum. In connection with the expansion, a new sintering plant will be constructed, with a capacity of about 400 tons a day. The installation will also comprise a new pumping system with daily output of 9,000,000 gallons of water, two new boilers of large capacity; two new blowing engines with output of about 45,000 cubic feet, and other auxiliary machinery. A new laboratory, office, warehouse, and other structures will be built. To provide for the expansion the company is disposing of a bond issue of \$4,000,000, about \$2,000,000 of which will be used for the new plant. Lewis W. Francis is president.

The Somerville Iron Company, Chattanooga, Tenn., has completed plans and will soon commence the construction of an addition to its plant for increased production. Equipment will be installed to double approximately the present output, making a total capacity of about 3,000 tons of iron per day. The extension, including equipment, is estimated to cost about \$65,000.

The Dowling Iron Works, Lincoln, Neb., has plans under way for the construction of an addition to its plant for increased production, comprising a one-story building, totaling about 2,500 square feet of floor space. Considerable new equipment will be installed. A. C. Koenig, Bankers Life Bldg., Lincoln, is engineer.

The Struthers Furnace Company, Youngstown, Ohio, is disposing of a bond issue of \$1,500,000, a portion of the proceeds to be used for expansion, general operations, increase in working capital, etc. The company operates a blast furnace with capacity of about 15,000 tons of pig iron per month, average, and has recently completed a new power house, with pumping plant rated at 18,000,000 gallons per days. It is affiliated with the Cleveland-Cliffs Iron Company, in the ownership of the Wade and Helmer Mines in the Missabe Iron Range.

The Newton Steel Company, Youngstown, Ohio, manufacturer of steel sheets, etc., will soon take bids for the construction of a number of additions in its plant for increased production, estimated to cost in excess of \$600,000, including equipment. The main feature of the work will consist of six new sheet mills and auxiliary operating departments.

The Duffin Iron Company, 4837 South Kedzie Avenue, Chicago, Ill., is planning for the construction of additions to its iron and steel works for increased production. A main two-story building will be erected, to cost about \$25,000. John Duffin is president. Mundie & Jensen, 39 South LaSalle Street, Chicago, architects, are in charge of the work.

The Armstrong Steel Company, Fort Worth, Texas, recently organized with a capital of \$2,500,000, has acquired the plant and business formerly operated under the name of the George W. Armstrong Steel Company. Preliminary plans are being prepared for the construction of a large addition to the present steel mills, for the production of general steel and iron products. At a later date it is proposed to construct a number of new mills for different character of production. A consideration of about \$1,250,000 has been given for the property. Employment of 600 men, as heretofore, will be continued, and it is proposed to double this working force in the near future. George W. Armstrong, head of the acquired company, will occupy a similar position with the new organization.

The Wanner Malleable Iron Company, Hammond, Ind., has preliminary plans under way for the rebuilding of the portion of its plant recently destroyed by fire, with loss approximating \$100,000, including equipment. The heaviest damage occurred in the soft rolling mill and the assembling works.

The Palmer Steel Company, Holyoke, Mass., recently organized with a capital of \$100,000 to manufacture iron and steel products, including structural shapes, etc., has acquired a tract of about 14 acres of land at Meadow Street and McKinstry Avenue, as a site for its proposed new plant. The initial works will consist of a one-story building, about 70x200 feet, to be equipped for steel fabricating, and estimated to cost in excess of \$50,000. At a later date, additional plant units will be constructed. Earl Palmer is president and Wayne F. Palmer, 7 Montgomery Avenue, Holyoke, treasurer.

The Riverdale Rolling Mill Company, 80 East Jackson Boulevard, Chicago, Ill., will commence the immediate erection of an addition to its plant at East One Hundred and Thirty-seventh Street and the Illinois Central Railway Tracks, Riverdale, near Chicago. It will be one-story, 65x140 feet, and is estimated to cost in excess of \$40,000. The construction contract has been awarded to the Austin Company, 208 South LaSalle Street, Chicago.

The Darlington Iron Works, Darlington, S. C., is planning for the rebuilding of the portion of its plant recently destroyed by fire. Damage was sustained in a number of buildings, including equipment. The exact amount of loss has not been estimated.

The Vulcan Iron Works, Galveston, Texas, has plans under way for the construction of a number of additions to its plant for increased production, estimated to cost in excess of \$75,000.

PRODUCTION TOPICS

THE PURCHASE OF REFRACTORIES*

By W. A. HULL, Chief, Refractories Section,
Bureau of Standards, Washington, D. C.

PART II

The activities of your Association have unquestionably had much to do with bringing the refractories manufacturers to a state of mind necessary to a whole hearted cooperation in a job like that. Association activities have a remarkable effect on the members of an association and on an industry. We have seen how it works out in other industries and it requires no supernatural vision to see how it is working out in yours.

One of the things that has been made evident by these conferences that have been held at the Bureau of Standards is that there is a wealth of information about refractories under cover. Perhaps it is too soon to expect it to come out; perhaps the Association is not ready to take the step; but if the cards could all be laid on the table, face up, it would go a long way toward straightening out the whole refractories situation.

What I mean is this: a steel company or a corporation which builds coke ovens makes tests and keeps records of performance and the results, except for certain general facts or conclusions are held as confidential information; the individual refractories manufacturers and the Refractories Manufacturers Association make tests and get, when they are able, records of performance, and the results are held as confidential; the Bureau of Standards makes a valuable investigation in which the properties of something like seventy brands of fire brick are determined and the results, so far as the names of the brands are concerned, are held as confidential. Think what a help it would be, in the writing of specifications and in the intelligent purchase of refractories, if all this information could come out in the open. I would hardly have the hardihood, at this time, to ask that such a course be followed. I realize that you manufacturers would hesitate to see your pet brands paraded for inspection, stripped of all the bunk and mystery with which your salesmen have kept them clothed and padded for decades: but I want to point out the alternative.

For a long time, we have been deceiving ourselves with the idea that the trouble with the refractories situation is that the user will not pay the price for the quality and the workmanship and the uniformity that he is demanding in refractories and that consequently, we cannot give them to him. Well, whose fault is it if he will not pay the price? Are most of the big users afflicted with some chronic sort of refractomania, which prevents them from following a sound policy in the purchase of this particular class of supplies? Are most of them so lacking in co-ordination between the purchase office and the production and accounting departments that they pay no attention to the effect of the quality of refractories on the cost of a ton of steel or whatever their product may be, or is it possible that they are doing the best they can with the information available?

Is the real trouble the lack of a market for really superior refractories, or difficulty in getting better prices for

the common run of refractories. Suppose a purchasing agent does buy the cheapest one of a number of good brands of fire brick rather than the best. Perhaps it is poor economy to do that, but if so, why does he do it? Is it simply that the purchasing agent is unduly zealous in the matter of making a record or is it a part of a definite policy of his company? What might you or I do in his place? A number of brands of brick are available, any one of which is known to be suitable for a given purpose. There is a considerable difference in price between what we may term the aristocrats of the lot and some of the more lowly ones. No useful facts are available for the guidance of the purchasing agent in evaluating these brands except their general reputations and the records of the production departments; and it has been demonstrated that it is next to impossible to make accurate comparisons of the service of similar kinds of fire brick because of the irregularities and the accidental features of service conditions. What is the reasonable thing for the purchasing agent to do? Can you blame him very much if he solves his problem by driving as hard a bargain as he can and buying that one of a number of suitable brands which he can buy for the least money?

In taking advantage of low prices, a user faces the prospect that he may run into difficulties from variations in quality, from bad workmanship and various defects that he might not encounter to the same extent if he were to purchase from a company which maintains higher standards in these things as well as in price. This does not necessarily follow, however, and the user may feel that he can afford to take the chance, safe-guarding himself meanwhile by a rigid system of inspection and testing. Isn't this a fairly reasonable explanation of the procedure followed by some of the consumers and isn't it possible that they are getting away with it to the disadvantage of the refractories industry? Isn't it just possible that the whole industry is suffering from the effects of the secrecy about brands? If the manufacturer who is selling his product at a comparatively low price, had definite figures to show that his brand of brick is as good as he thinks it is—knows it is, possibly, then he might have the nerve to hold out for a decent price and get it. Henry Ford is credited with saying "Never lock up your engineering department—you may lock out more than you lock in." It seems worth while to consider whether manufacturers do not lose more than they gain when they keep some of their information confidential.

At the Bureau of Standards, we know from the inquiries that we receive, that consumers are eager for information about the qualities of different brands of brick. We do not give it to them because it is confidential information and to that extent we help to keep men in ignorance who are eager for facts. There are two things that in normal times keep the prices of refractories down—the law of supply and demand, and ignorance. Users refuse to pay a premium for superior quality simply because they have no way of knowing they are going to get it. They may not even know when they do get it.

Now the law of supply and demand is something difficult to overcome but the other factor can be controlled and if producers could overcome their inherent bashfulness about brands it would speed up the process of education amazingly.

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L. H. Miller, formerly connected with the Cleveland office of the Bethlehem Steel Company, has resigned to become managing director of the newly organized National Steel Fabricators' Association, the object of which is the establishment of standards for the guidance of steel fabricators with the view of bringing about uniformity in steel building construction and the conserving of steel used for this purpose.

R. M. Rice, purchasing agent, La Belle Iron Works, Steubenville, Ohio, recently resigned to go into business for himself in Wheeling, W. Va. His successor has not been announced.

C. J. Madjett, has been made general manager of the London Bridge Works, London, Ont. Mr. Madjett was formerly manager of the Standard Steel Construction Company, Welland, Ont.

J. T. Osler, who has been connected with the Hubbard Steel Foundry Company, East Chicago, Ind., in the capacity of manager of the roll department, was recently appointed general manager.

Charles J. Graham, who is vice president of the recently reorganized Graham Bolt & Nut Company, in which the Jones & Laughlin Steel Company now is largely interested, has been appointed special sales representative for the latter company.

Several changes were made in the personnel of the subsidiaries of the Wheeling Steel Corporation at a recent meeting of the board of directors. D. Allen Burt, who besides being vice president and treasurer of the Wheeling Steel Corporation has been president of LaBelle Iron Works, has become chairman of that company and is succeeded as president by A. J. McFarland, who a few months ago was made general manager of this company. W. W. Holloway has been made president of the Whitaker-Glessner Co. succeeding Andrew Glass, who has held that position besides that of vice president in charge of operations of the Wheeling Steel Corporation. George W. Moore, general manager, Portsmouth, Ohio, works, Whitaker-Glessner Company has been named vice president of the company.

John McConnell, vice president in charge of operations of the United Alloy Steel Corporation, Canton, Ohio, and Elton Hoyt of Cleveland, have been elected directors of the United Alloy Company succeeding J. A. Buell and E. L. Hang.

L. P. Ross was recently elected vice president in charge of operations of the Replogle Steel Company.

H. D. Scott, assistant superintendent Yorkville, Ohio, Works, Wheeling Steel Corporation, was recently promoted to the position of superintendent to fill the vacancy caused by the resignation of E. T. McNulty, who has become affiliated with the Charcoal Iron Products Co., Washington, Pa., as general manager.

R. E. Zimmerman, director of the research laboratory of the American Sheet & Tin Plate Company, Pittsburgh, has been appointed assistant to the president, effective May 1, succeeding the late Robert Skemp.

George Croak has been made general manager of Palmer Foundry & Machine Company, Palmer, Mass. Mr. Croak was formerly foundry superintendent of Athol Machine Company, Athol, Mass., and associated with the Becker Milling Machine Company, Hyde Park, Boston, previous to the former.

John N. Allen has been appointed purchasing agent, Donner Steel Company, Buffalo, succeeding E. L. Hendrickson. Mr. Allen, who resigned as manager of the mining and transportation department, Brier Hill Steel Company, Youngstown, Ohio, in 1919, to become vice president of the National Sales & Trading Company, Cleveland, was connected with the Lackawanna Steel Company for a number of years, prior to going to the Brier Hill Steel Company.

Charles J. Thompson was elected president and general manager of the Empire Tube & Steel Corporation, College Point, L. I., at a recent meeting of that company. Mr. Thompson for two years had been secretary and treasurer of that interest. L. J. Roine, who had served as assistant secretary, was elected treasurer, and J. J. Clegg, formerly auditor, was elected secretary.

James B. Tate has been made general purchasing agent for the Pressed Steel Car Company and its Chicago subsidiary. Mr. Tate had been acting purchasing agent for the past few months and is successor to J. H. Hackenburg, resigned.

William C. Bulmer has resigned, effective June 1, as superintendent of the open-hearth and Bessemer departments of the Carnegie Steel Company at the Ohio Works, Youngstown, a position he has filled for the past six years, to assume charge of a department of the Blaw-Knox Company, Pitts-



burgh, principally connected with water-cooling appliances for open-hearth furnaces and with the sale and installation of the McKune type of furnace.

Ledlie I. Laughlin, son of James B. Laughlin, former treasurer of the Jones & Laughlin Steel Company, Pittsburgh, who has been in the Pittsburgh office and mills of the company for several years, has joined the New York sales office. Mr. Laughlin is a director of the company and is seeking experience in all branches of the company's activities.

William Hutton Blauvelt has resigned his position with the Semet-Solvay Company, of Syracuse, N. Y., and has opened an office as Consulting Engineer, in the Equitable Building, 120 Broadway, New York City, where he will give special attention to the carbonization of fuels, and allied subjects. Mr. Blauvelt has been connected for many years with the Semet-Solvay and Solvay Process Companies, and has taken a prominent part in the development of the by-product coke industry in America. On account of his broad experience in the carbonization of coal, production of gas for domestic and industrial purposes, the recovery of by-products and the general utilization of fuels, he is a recognized authority on these subjects. The first important installation of by-product recovery gas producers, of the Mond type, was brought to this country and put into operation under his direction during the earlier years of his association with the Solvay companies.

Stewart M. Marshall of Perin, Marshall & Estep, consulting engineers, New York, has left India and is returning to the United States by way of England.

Harry Brown recently tendered his resignation as technical manager and as a director of the Bethlehem Shipbuilding Corporation, Ltd. Mr. Brown will leave for an extended vacation.

David B. Rushmore, Chief Engineer of the power and mining department of the General Electric Company has been appointed to the staff of consulting engineers of the company. His promotion is to enable him to devote his time more fully to general engineering problems. He is succeeded by K. A. Pauly.

Francis J. Hall, vice president of the Central Iron & Steel Company, Harrisburg, Pa., and connected with the company for the past 20 years, has resigned, effective May 31st.

Henry Marion Howe died at his home at Bedford Hills, New York, on Sunday, May 14th, 1922, from a malady which had confined him to his house for more than a year. Mr. Howe was born March 2nd, 1848, at Boston, Mass. His father was Dr. Samuel G. Howe famous for his service to Greece in her war for independence (from 1824 to 1830) and later for his labors in the instruction of the blind. His mother was Julia Ward Howe, author of *The Battle Hymn of the Republic*, and leader in many reforms. He was graduated in 1865 from the famous Boston Latin School, and four years later received his degree as Bachelor of Arts from Harvard College. Thus equipped, he entered the Massachusetts Institute of Technology, which gave him in 1871 the degree of "Graduate in the Department of Geology and Mining Engineering"—a cumbrous title for which the institution substituted, a few years later, that of "Bachelor of Science." And Harvard made him Master of Arts in 1872, and Doctor of Laws in 1905.

With the exception of approximately five years devoted to the metallurgy of copper, during which he inaugurated copper smelting in Chilt, designed and built the works of the Orford Nickel & Copper Company at Capelton and Tustis, in the Province of Quebec, Canada, and at Bergen Point, N. J., and managed the Pima Copper Mining & Smelting Company in Arizona, Dr. Howe's whole professional life had been devoted chiefly to the development of the iron and steel industry, as superintendent of steel works (Joliet, 1872, and Pittsburgh, 1873-4), consulting metallurgist, teacher of metallurgy, investigator, interpreter, writer and presiding officer. While acting as consulting metallurgist he was lecturer on metallurgy at the Massachusetts Institute of Technology from 1883-1897, professor of metallurgy at Columbia University, 1897, 1913, and professor emeritus, 1913-1922.

Frank Gibbons, who has been in the general offices of the Central Steel Company, Massillon, Ohio, for a number of years, has been appointed sales manager for the Cleveland district of the company with offices at 904 Swetland Bldg., Cleveland.

Samuel M. Vauclain, president of the Baldwin Locomotive Works, and John C. Neale, vice president and general manager of sales of the Cambria Steel Company, have been re-elected directors of the Cambria company for a term of three years.

Some Pointers on By-Product Coke Oven Operations

PROGRESS IN BY-PRODUCT GAS UTILIZATION

By H. DOBRIN*

For a brief consideration of our subject, and omitting the use of fuel in the blast furnace and boilers, let us start at the soaking pits, following on to the reheating furnaces, and through the fabricating divisions, to the remote corners where we find the blacksmith's forges.

The classes of fuel generally met with in the average steel plant are by-product gas, producer gas, oil, tar, coal and coke. The by-product gas from coke ovens does not always suffice for all the heating operations of the plant. Especially is this the case where a fabricating plant of small steel products is operated in conjunction with the blooming, structural or plate mills. Auxiliary plants of either producer gas, oil or powdered coal are therefore operated in conjunction with the available by-product gas.

The Soaking Pits.

Wherever by-product gas is available, its use for heating ingots for the blooming mill offers an ideal application. Where there is an occasional shortage, producer gas serves as a fine auxiliary. In some plants producer gas serves as the principal fuel, and by-product gas is used as an auxiliary.

That the latter gas is an ideal fuel for the soaking pit, is now an established fact in a good many steel plants. Time was, and for that matter still is, when all the ills incident to blooming mill operation were laid at the door of by-product gas used in the soaking pit. In the plants where its practicable and profitable use have been learned, one does not hear any more complaints of burnt steel or slow heating.

It is also well known that by-product gas is not as severe on the refractories of the soaking pit as is oil or producer gas.

Remember that, whatever producer gas or oil can do, by-product gas can do as well, in fact, better, and if there is any steel plant that has been unsuccessful in getting good results from the latter fuel, it is not the fault of the fuel by any means. A few small changes, either in the arrangement of the piping, or the taking out or the adding of a brick here and there, often constitute the difference between success and failure on this application.

Reheating Furnaces.

Coming to the reheating furnaces, we have now an even more suitable application for the by-product gas than at the soaking pit. If you have an auxiliary fuel for the soaking pits you should hardly require one for the reheating furnaces.

Here we may perhaps put our finger on one cause of high fuel costs—auxiliary fuel plants are often installed in too many departments. If you would analyze and definitely determine your fuel requirements, as well as your minimum available by-product gas supply, and then select the operations for which this gas is most ideally suited, and allot the gas to such operations, you would find it possible to dispense with a good number of auxiliary fuel installations. Give your fuel co-ordination the same care and attention that you give your power co-ordination.

The furnaces and operations for which the gas is best suited should then have the first call on the available supply. To avoid confusion, the gas could be pumped and delivered at a high pressure to the first-call units, and the other mills, not being so equipped, could not get the gas, except in periods when the sup-

ply is abundant, and would have to resort to their auxiliary fuel.

It is freely predicted by the writer that by-product gas will soon be the only fuel that steel mills will use in their reheating furnaces, providing this gas is at all available. This prediction is based on the success of a recent experiment in a steel plant where the checkers and stack of a reheating furnace were entirely eliminated, and the fuel cost, per ton of steel rolled, has for some months been consistently and steadily lower than the fuel cost on the old type regenerative checker furnaces. Nor has the fuel cost practice on this direct-fired, non-regenerative furnace been poorer than is the average fuel cost practice in most mills. The heating quality of this furnace compares more favorably with the old-type furnaces both as to speed and uniformity, besides considerably reducing slag losses. As there is no underground work whatever on this furnace, you will readily see that the first cost does not begin to compare with the old type furnace. This furnace still has to be perfected along mechanical lines, but in view of the advantages that it seems to offer, it will not be long before it will be perfected.

Fabricating Mills.

Here is a part of the plant where there is room for improvement in almost every case. Especially is this true where the plant manufactures bolts, nuts, rivets, large and small forgings, and the multitude of other small steel products. The same applies to the plant which does a good deal of annealing, also welding.

In going through a forging or annealing shop, it is not uncommon to find the use of oil, tar, blacksmith's coal and coke, in addition to the by-product gas. And in order that the combustion of the above fuels may be facilitated, steam lines for the oil combustion, as well as a multitude of low pressure air blowers and high pressure air compressors for the gas combustion, have had to be installed. In addition we find the coal car siding for the dumping of the blacksmith's coal. Then the laborers required for wheeling the coal and ashes and cleaning the blacksmith's forges. It is now definitely established that by-product gas can displace all the above mentioned fuels, as well as the steam, low and high pressure blowers, coal and ash handling, and all the dust and smoke. A cleaner and speedier welding operation can be performed with gas than with either coal or coke, and, without fear of contradiction, at practically one-tenth the cost. It is all a matter of correct application of the gas, and a thorough control of the mixture of gas and air. This can be very well done, in view of the present stage of development of the art.

Now getting down to the general lay-out of a fuel conservation program, or rather a fuel cost-reducing program, it is well to bear in mind that the smaller the furnace the more ideal is the application of gas for it, and the more refined the operation or the product, the more ideally is by-product gas suited for same. So, in laying out a plan, it is best to start with providing the smaller operations and furnaces with gas, and, of course, affording them first call on the gas. It is obviously simpler and cheaper to turn the auxiliary fuel on a row of soaking pits than to cause 40 or 50 small furnaces to go on an auxiliary fuel.

In a steel plant where all the furnaces in the fabricating division were converted to a single fuel—by-product gas—and where the use of oil and coal was entirely eliminated, thereby also dispensing with the need for steam, air compressors, low pressure air blowers and coal handling facilities, the resultant savings were a revelation, and exceeded by far the best expectations of the management.

*Consulting Fuel Engineer, Birmingham, Ala.

TRADE NOTES

The American Industrial Engineering Company, Chicago, has recently taken an order from the Tennessee Coal, Iron and Railroad Company for the installation of complete low pressure pulverized coal burning plant for utilizing pulverized coal as fuel under one of the boilers in that company's new power plant at Ensley, Alabama.

The Gas Combustion Company of Pittsburgh, Pennsylvania, has recently filled its fourth repeat order for Bradshaw Burners at Carnegie Steel Company, New Castle Plant, New Castle, Pennsylvania. They have also received an order to equip the new boiler plant of The Tennessee Coal, Iron and Railroad Company at Ensley, Alabama with the Pressure Type Bradshaw Burner.

Metal & Thermit Corporation, New York, announces the removal of its Pittsburgh Branch Office from 1427 Western avenue, to 801-807 Hillsboro street, Corliss Station, Pittsburgh, Pa.

The Atmospheric Nitrogen Corporation has ordered from The U. G. I. Contracting Co., of Philadelphia, additional equipment for its blue gas plant at Syracuse, N. Y.

The La Belle Iron Works of the Wheeling Steel Corp., Steubenville, Ohio, have taken definite action to greatly increase both efficiency and production of the open hearth furnaces at their plant. One of the furnaces has been rebuilt after the McKune plan and sixteen additional Chapman Floating Agitators with automatic feed are being installed. These sixteen are in addition to four already in service, thus equipping a large portion of the gas producers supplying the furnaces. Previously each furnace was supplied by four 8 ft. inside diameter hand-poked producers. As a result there was usually a shortage of gas. Now three producers equipped with agitators easily take care of each furnace, giving a uniform supply of high grade gas so essential to secure better furnace operation and increased production.

The U. G. I. Contracting Co., of Philadelphia, has received a contract from the Northern Indiana Gas & Electric Co. for the installation of 15 ft. circular steel purifiers to be installed at Michigan City, Ind.

The American Supply Company, 135 Washington St., Providence, R. I., has been appointed agent for the Providence district to represent the Quigley Furnace Specialties Company of New York, manufacturers of HYTEMPITE. The Quigley products are warehoused in Providence for quick delivery to local points.

The Electric Furnace Construction Co., Philadelphia, advise that the Electric Steam Generator of the "Kaelin System" recently installed at the Laurentide Paper Co., commenced operating April 21st. Although only designed for 25,000 kilowatts, this boiler is averaging 34,000 kilowatts and is producing 100,000 lbs. of steam per hour at 125 lb. pressure.

The Western United Gas & Electric Co. has awarded contract to The U. G. I. Contracting Co., of Philadelphia, for the installation of one (1) 11 ft. cone top set of Carburetted Water Gas Apparatus and two (2) Waste Heat Boilers to be installed at the Joilet, Ill. plant. Included in the water gas installation will be one (1) U. G. I. Automatic Control.

The Taylor-Wilson Manufacturing Company, McKees Rocks, Pa., has recently opened a Sales Office at 1212 Park Bldg., Pittsburgh, Pa. This office is in charge of Mr. Wm. Y. Banks, Jr., as Special Sales Manager.

The Sharon Pressed Steel Company on May 1st will move their office from No. 66 Broadway to their new warehouse in the Dodge Building at No. 47 West Broadway, corner of Murray street, where they will carry for demonstration a complete line of trucks, trailers, skids and other pressed steel products.

TRADE PUBLICATIONS

Adam Hilger, Limited, Optical Works, 75 A Camden Road, London, N. W. 1, have issued a very interesting pamphlet descriptive of their chemical spectrometer. It contains information also regarding the use of this instrument.

W. S. Rockwell have issued Bulletin No. 242. "The Influence of Method of Heating and Handling on Quality and Cost of Heat-Treated Products," summarized in this Bulletin, should interest those concerned with the problem of producing better products at less cost, because of reference to essential factors generally overlooked in practice and illustrations of the practical application of the principles outlined.

The Scientific Materials Company have issued a pamphlet describing "The F and F Optical Pyrometer." This instrument is used to measure the temperatures in Fuel Beds, Heat Treating Furnaces, Coke Ovens, Open Hearth Furnaces, Soaking Pits and other locations where high temperatures are obtained.

Paul Haehler Co., Chicago, Ill., has issued a new catalog which describes in detail its line of industrial ovens. The construction of Maehler ovens is given, as well as data on ventilation and circulation, assembling or setting up, fuels for industrial ovens, gas-heated ovens, electric heat and its adaptation to Maehler

ovens, conveyor and special type ovens, core ovens, potash tanks and boiling cauldrons and oven accessory equipment. The booklet is well illustrated.

The Page Steel & Wire Co., Monessen, Pa., has just issued a new handbook describing and illustrating interesting developments in the welding field.

The Aeroil Burner Co., Inc., Union Hill, N. J., has just received from the press its new bulletin, No. 20, on "Oil-Burning Appliances."

Clement K. Quinn & Co., Duluth, Minn., has issued its 1922 Analyses of Lake Superior Iron Ores.

The Grindle Fuel Equipment Co., Harvey, Ill., has issued its first general catalog on Grindle powdered fuel equipment, which contains 40 pages of text and illustrations. The advantages of powdered fuel in general is given and the advantages and operation of the Grindle system in particular. Copies will be sent to interested parties on request.

The Chapman-Stein Furnace Co., Mt. Vernon, O., is circulating four separate bulletins on industrial furnaces under one cover. These furnaces are of the recuperative type, in which the air and usually the gas, are both preheated by passing through chambers previously heated by the spent gases. The furnace applications described in the bulletins include rolling mill use, forging and annealing. The data given are complete and very interesting.

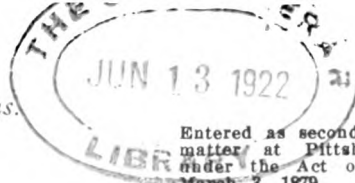
The Peabody Engineering Corp, New York, has published an 8-page illustrated bulletin in which a mechanical atomizer and air register is described. This air register is designed to give absolute control of the air supply under varying load conditions. The shutters are so arranged that they give the air current the correct amount of rotation for all loads, and the register is so constructed that all the shutters may be placed in the position to give the right amount of air for perfect combustion by turning a handle.

The R. J. Teetor Co., Muskegon, Mich., is circulating an illustrated folder in which attention is called to its line of molding machines. Three models are described.

The Independent Pneumatic Tool Co., Chicago, has published a small folder in which pneumatic drills for light work, drilling, reaming, wood boring, screw driving, cleaning, polishing, removing scale, paint or rust are described and illustrated.

The Shepard Electric Crane & Hoist Co., Montour Falls, N. Y., is circulating a 4-page illustrated bulletin in which an electric hoist is described and illustrated. It is claimed this hoist has a wide range of application. Details of construction are given in the folder.

Member of the Audit Bureau of Circulations.

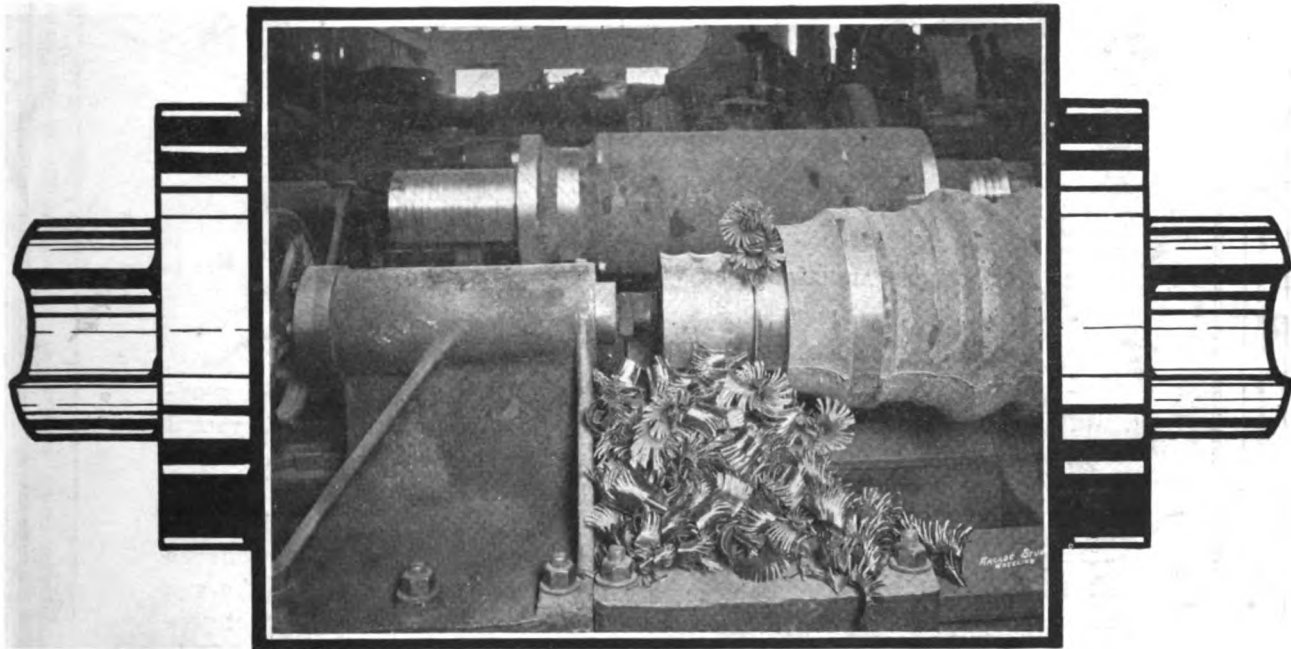


Entered as second class mail matter at Pittsburgh, Pa., under the Act of Congress, March 3, 1879.

The Blast Furnace *and* Steel Plant

Pittsburgh, June, 1922.

WHEELING QUALITY



The Mo-lyb-den-um Roll
Wheeling Mold & Foundry Company
Wheeling, West Virginia

PENINSULA PLANT

WARWOOD PLANT
MANCHESTER PLANT

	Capacity Per Month
Steel Castings and Steel Rolls.....	3000 Tons
Iron Castings	1000 "
Sand and Chilled Iron Rolls.....	1000 "
Small Iron Rolls.....	500 "

See Article on Pages 358 and 359.